The Tyrannosaurus, a carnivorous mechanism, interpreted as an offensive energy complex

THE ORIGIN AND EVOLUTION OF LIFE [See page 292]

Hours of Labor*
Industrial Fatigue and Output in England

IN an account given a year ago in the *Engineering Supplement* of the position in this country of the study of industrial fatigue it was pointed out that much of the considerable amount of investigation that had been going on for some time was merely the experimental reiteration of what had been established long before both in the laboratory and by practical experience. It had added a detail here and there to the sum total of what was previously known; but as a whole it had made no such addition to previous knowledge as urgent needs demanded.

It cannot be said that the situation has changed greatly in the last twelve months. The investigation of hours of labor has been continued, and experience has been extracted from the records of a number of firms which furnish additional information of unquestioned value. Yet when all that has been published is considered, the impression remains unaltered that the scale on which this subject of industrial fatigue or hours of labor is being investigated is not reasonably commensurate with its immediate and prospective importance to British industry, and that what has been published affords little evidence that engineers are taking the part in the inquiry they must ultimately take if the result is to serve the practical purpose that is in view.

RECENT RESULTS

Nevertheless, it must be recognized that work on the subject has proceeded steadily and has yielded results which, as far as they go, are of value and ought not to be overlooked. In particular, the Health of Munitions Workers Committee set up by the Ministry of Munitions has published data which, if they do not by themselves lead to any broad fresh conclusions, do add further and opportune confirmation to what is known already. This is not the less important by reason of the fact that these results are as a rule better known than practised. Experience shows that what has long been known and not acted on is apt to become irredeemably obsolete, and, like certain parasites, can attain active life only after it has been given to the world again by some modern discoverer. In itself, therefore, the fact that the data gained during the past year announce no principle that was not well established by previous work and experience does not make them valueless. What is to be regretted is merely that they do not extend to more numerous and more definite conclusions than has been possible with the staff and facilities employed on the investigations.

One result, the effect of night shifts, though it cannot be applied generally without precautions and reservations, and has not been submitted as established for all circumstances, goes perhaps further than the others into new ground. As the matter stands at present, it appears that night shifts alternated every week or two with day shifts are distinctly less injurious to output and time-keeping than continuous night shifts. Nothing has been disclosed to displace the present accepted belief that night shifts in any combination are sensibly unfavorable to health; but as a conclusion to be used in emergencies such as the present, when at the cost of anything short of the permanent breakdown of the worker's health the paramount consideration is output, the comparison that has been made between continuous and discontinuous night work to the disadvantage of the continuous system may be taken provisionally as a sound working result, and must be borne in mind in any further revision of hours involving night work.

THE ONE-BREAK DAY

Another publication of the Health of Munition Worker's Committee, a study by Professor Loveday of the causes and conditions of lost time, is notable not so much for disclosing new results as for the frankness with which it acknowledges the limitations within which the subject had to be considered. It was based mainly on the author's inspections of a variety of factories in Great Britain, and on several heads collects a considerable mass of information which is cogent by reason of its volume and concurrence; but it is prefaced by the remark that "the variables are so numerous as between different factories, and even as between different departments in a single factory, that more weight ought properly to be attached to coincidence or divergence of opinions among experienced persons than to coincidence or divergence of figures." Doubtless this view is somewhat homoeopathic, purporting to treat disadvantages arising from uncontrolled variables by introducing yet more variables—the personal equations of the experienced persons and

of the author—which may be even less controllable. But this attitude has at least the great advantage of preventing the observer from riding his figures too hard; and when, as in Professor Loveday's memorandum, it is accompanied by a considerable collection of sporadic significant facts and sets of figures, the result, though it may not be quite as amenable to the academic methods of statistical study that are accessible in text-books, may be of greater value for practical purposes than others in which the orthodox statistical mechanism is applied with some pomp to material that is not strong enough to bear it.

WORK BEFORE BREAKFAST

Perhaps the most notable part of this memorandum is the discussion of the effect of work before breakfast. The survival of the before-breakfast "quarter" is a curiosity of works practice. There are very few shops in which it has not long been known to be notably less efficient than any other part of the day—less trustworthy in attracting men to work, and of less use when it has attracted them. Yet up to the present only a numerically trifling minority of works have taken their courage in their hands and cut out before-breakfast work altogether. Professor Loveday has collected experience from a number of shops engaged in various branches of manufacture, showing more or less satisfactory working of shifts up to 53 hours a week (and more with overtime) with work starting after breakfast. In some of these this system followed the ordinary two-break day, and the results are compared. In one instance highly suggestive results are given from a large firm of engineers with three factories in the same district. Two of these factories are in a large town, and employ some 7,000 and 1,500 hands respectively on a two-break day beginning at 6.45 A. M.; the third is in a neighboring small town with 1,500 hands on a one-break day. All three work 53 hours a week. The time lost through sickness appears to have been about the same in all the works; but the time lost avoidably, while moderate in the town factories (apparently of the order of 3 per cent of total normal hours) was of the order of 0.1 per cent, or practically negligible, in the one-break factory. A similar result is seen in comparing the numbers of men who lose time—something over thirty per cent in the two-break factories, against one per cent in the third. One of the two-break factories adopted the system only a few years previously, and its over-all loss of time under its previous system, which was identical with the one-break system of the third factory, was then little more than half what it is now, and not much greater than the present figure for the one-break factory.

In their net outcome the instances given in the memorandum point to work without food rather than length of hours as the dominant factor by which output is depressed in the two-break day, though other considerations indicate that in many classes of work there is no gain of output in extending hours to the limits that are generally worked. In some instances, indeed, men earned more in the shortened day, after they had settled down to the new system, than they had earned previously.

STATISTICAL DATA

The latest publication of the same Committee is a continuation of Dr. Vernon's statistical inquiry, noticed in these columns last November. Its most notable feature is that it extends to more than a twelvemonth some observations of which the former report described some five months' figures. The observations are exceptional not only in their duration but in including a fair number of workers through changeable hours, and on the whole they point to conclusions as definite as could be expected in the circumstances in which they had to be made.

One set of observations relates to a group varying from ninety-five to eighty women turning aluminium fuse bodies. Their average hourly output, taken as 100 for the month before Christmas, 1915, during which they worked an average of 66.2 hours a week, rose ultimately in the next 12 months to 158, by which time the hours of work had fallen to 45.6; there was therefore an increase of nine per cent in gross weekly output in spite of—or perhaps more truly because of—working 20.6 hours fewer a week. The work was done on capstan lathes with seven tools. A group of 40 women on threadmilling in semi-automatic machines, starting in the pre-Christmas period with a week of 64.9 hours, increased the hourly output after 11 months to 133, the hours of work falling to 48.1; so that the gross weekly output was within one per cent of the November-December output, though 16.8 hours

fewer were worked in the week. Another group of 56 men sized fused bodies by screwing them through a die; and the dies in the previous operation seem to have been rather worn, or the work left rather full in diameter, as the job, when Dr. Vernon inspected it, struck him as heavy labor imposing a great strain on the workers. Here the average November-December hours were 58.2, and in the following December the hourly output had risen to 139 against a reduction of hours to 51.2, the gross weekly output thus being 22 per cent more than at the start for seven hours a week less work. A small group of 15 youths, again, were boring top caps in semi-automatic machines, and worked 72.5 hours a week at the start, falling by July-September to 54.5 with an hourly output of 129; their gross weekly output, with 18 hours less work, was three per cent less than with the longer hours.

THE ACADEMIC METHOD

These are some of the data described in Dr. Vernon's memorandum; and if it had stopped with them and similar results it would have been a modest but appreciable contribution to the statistical verification of what has been already shown in experience. More than that, its results without comment or addition would have to be taken into account in any attempt to fix the optimum working day for work of the classes examined. As a fact the figures are presented week by week after April 16th, the date at which those of the author's previous memorandum stop; and this detail, enabling a reader to follow the variations of hours and output, adds to the value of the record. The author vouches for the constancy of working conditions throughout the period of observation, and with that guarantee the figures may be left to speak for themselves as a contribution to the subject that cannot be left out of account.

The figures, however, are not left to themselves, and the author puts forward conjectures to explain many of their variations. In the group of fuse-turning women, for instance, attention is drawn to the rise of average hourly output to 123 between February 27th and April 16th, which accompanied a fall of average hours from 66.2 to 54.8. A reference to the earlier memorandum, however, shows that already in the period January 9th to 23d the hourly output had risen to 111 for a working week of 68.6 hours. It is quite open to the author to conjecture that this rise is the residual effect of the Christmas holiday, and as such may be ignored when comparing the week of 66.2 hours with that of 54.8; but it is scarcely open to him to get rid of the *prima facie* objection which this rise offers to his argument by omitting the record of it from the figure he presents.

LIMITATIONS OF INDUSTRIAL SCIENCE

In a similar spirit Dr. Vernon suggests what he believes to be an unexceptionable method for testing whether a set of figures of output is influenced by trade union restrictions, consisting merely in fitting them to a common frequency curve; the idea being that if restrictions are present the high output side of the curve will be blunted instead of being symmetrical with the other side. On this hypothesis he shows the outputs of the fuse-body turners in successive periods, and as a control gives a similar curve for the output of women drawing cartridge cases in a machine which automatically limits their maximum. But it is by no means to be assumed that the restriction imposed by trade unions will operate as the automatic restriction of the pace of a machine, for the act of working below top speed is itself an adjustment that takes practice and skill and is done with varying success by different people. While the method may be interesting, a good deal of experience with it would be necessary before an assumption of its validity could be made.

If in fact, the best use is to be made of laborious and careful statistical investigations such as those for which industry is indebted to Dr. Vernon and others, the pride of academic science must be dropped, and observers who collect the statistics must be able to select and record any attendant circumstances by which their import may be affected. It would doubtless be more satisfactory to the observer to decide the matter by the help of his own speculations or by the authority of statistical science in its own right. But it must be remembered that pure statistical methods are useful only when they are applied to appropriate material. The judicious selection of the facts that may explain variations of figures better than the conjectures of an academic observer can be done only with the help of a familiar knowledge of the persons, conditions, and processes involved.

*Engineering Supplement of the London Times.

Air Mastery at Ypres

IN the *communiqués* bearing on the battle of Ypres only brief reference was made to the splendid work of the Air Service. From the War Correspondents' Headquarters now come a few details relating thereto:

"More than once in my despatches I have referred briefly to the part played by our airmen in the Ypres battle. Before the battle began—that is, by July 31 —they had, in spite of inferior observation during the last few days, established absolute control of the air over the whole battle area, just as they did on the Somme and at Messines.

"Then came that long spell of unprecedented weather, when for four days it rained continuously, and for nearly a week afterwards thick white mists hung over all the Flanders plains, so that work in the air was almost impossible. These were ten days of blessed rest for the German flying men. They could reorganize their shattered squadrons, bring up reinforcements, both of new machines to replace those lost and of those special auxiliary forces known as 'circuses,' which move from one point to another of the front, wherever they are most needed.

"More important than all, the individual pilots had ten days' rest for their nerves, ten long days in which they had every excuse for not going up, and in which our men could not get at them. So that when the air cleared again and fighting was once more possible our work had been largely undone, and we had a rejuvenated German Flying Corps against us. Since then fighting in the air has been continuous and of the most bitter description.

FALSE GERMAN COMMUNIQUÉS

"That the results of this fighting have been largely in our favor you know from the official *communiqué*, and I should like here to say a word about those *communiqués*, and the German counter-claim. You can unhesitatingly accept our statements as truth and the German claims in contradiction as unequivocally false. I speak with some knowledge, and it is a fact which has never yet been properly made public that all our statements as to wrecked German machines and the rest are modest and conservative to what some people think an excessively scrupulous degree. It would hardly be an exaggeration to say that our individual pilots *know* that anywhere from 20 to 30 per cent more German machines have been destroyed than we have taken credit for.

"When a pilot claims to have crashed an enemy aeroplane he must be able to produce evidence to prove it. He must have seen the machine hit the ground and observed the wreckage. But how is a man fighting at 10,000 feet to follow an enemy machine to ground and investigate, when he is probably being attacked by other enemies in the skies? All claims are carefully scrutinized at some three stages before they are finally admitted and published by the Higher Command, and probably in one third of the cases where the pilots get credit for having crashed enemy machines the claim is allowed only through the accident of some other airman, flying low at the time, having seen the descent from the clouds above and the actual collision with the earth, or some similar accidental corroborating evidence.

INFLUENCE OF WESTERLY WINDS

"I have also spoken before of the influence of the westerly winds, which are so prevalent here. Fighting nearly always drifts over the enemy's territory, and while he knows all about the machines, whether his or ours, that come down we have only ocular evidence from the skies above and only know that our machines are 'missing.' During the last few days the influence of these westerly winds has been very great, and yesterday (August 17) the German flying men were habitually endeavoring to decline combat when near the front lines, and, by slowly retiring, trying to draw our men further over their own ground, where even a small mishap may prevent our men, against the adverse wind, from regaining our lines.

"It is well known that Captain Ball knew he had destroyed over fifty enemy machines, but he had official credit for only forty-one. He was an extremely modest man, whose claims undoubtedly were under the truth. The same is true in proportion of Captain Bishop, the new air V.C., and of all the other British fliers who have a long list of enemy victims to their credit. It is characteristic of our British way of doing things that we minimize our achievements before the public, and it has this compensation, that the world can count with absolute confidence on any claim whatsoever which our Royal Flying Corps puts forward.

ESSENTIAL WORK OF THE R. F. C.

"Driving down enemy machines, as I have more than once explained, is only a minor and accidental item in the Flying Corps' work. The real essential functions of aeroplanes are, by observation, to assist the artillery and, by photographing and bringing intelligence to help the Higher Command in their battle plans. Secondary to these is the work of actual coöperation in the battle, as by flying low and firing on enemy infantry, and so forth. Fighting enemy machines is only necessary to prevent their interference with this more important work and to make it impossible for them to do similar work for their Army.

"During the last few days' fighting I have heard several times the statement that in the course of the battle the fire of the German batteries actually grew perceptibly and continuously less as they were put out of action by our guns. This is quite creditable. In the course of a single day our guns, guided by our aeroplanes, silenced 73 hostile batteries. Observation showed 21 gun-pits entirely destroyed and 35 others badly damaged. Eighteen explosions of ammunition stores were caused and 15 other fires. These are only the items of air work in a single day of battle, but their influence on the course of victory is obviously enormous.

ENEMY WORK BY NIGHT

"It is characteristic and significant that enemy airmen of late are taking more and more to working at night—dropping bombs behind our lines, and so forth —when observation is non-existent and everything is mere chance. It is mere window dressing and its influence on the course of the war absolutely *nil*. But the German airmen like it better than working in day-time, because they have less chance of meeting our men. When we raid, as we do daily, and drop perhaps a dozen or 20 tons of explosives, it is done in daylight, when we can choose objectives and aim with accuracy. And the amount of this daylight work exceeds the German night work probably tenfold.

"Besides these things there is all the variegated work which our airmen do in harassing enemy troops and communications behind his lines. I have spoken of this often before, but the volume of it is amazing. From early dawn, which is the best time, till dark our flying men are firing with machine-guns into enemy trenches and troops in shell-holes or marching on roads. They attack and silence batteries in action and dive down and wipe out machine-guns on the ground and anti-aircraft guns which are firing on them. They chase trains along railways, firing into engine cabs and through the roofs and windows of carriages. They find single lorries or columns of horse transport on the roads, and make the former turn turtle in ditches and stampede the latter. Even single men on highways behind the enemy's line are not exempt.

INDIVIDUAL EXAMPLES OF WORK

"Taking individual examples of a morning's work by different men on the same day this week we find one who went to attack an enemy aerodrome. He found a machine just about to rise from the ground, so he dived and fired into and wrecked it, then circled round and continued to shatter the wreckage. He made a tour of the aerodrome, firing into the sheds from below the level of the roof, but as no more life appeared he went away and found a German battery in action. He stooped at it and fired along the line of guns, silencing the lot. Then he 'sat on' the battery for five minutes lest it should recommence firing, but as it did not he jogged home and used the remainder of his ammunition on enemy trenches in passing.

"Another airman had a similar morning. He took on first an enemy aerodrome, then a battery, then a train, and finally the infantry in the trenches by Polygon Wood. Another had the luck to find a large body of troops on a road, so he went down and flew along above them, firing as he went, and when they had scattered and hidden in ditches and a wood the road was dotted with dead.

"Another spent his time at altitudes of from 50 to 100 feet. He found three enemy machines getting ready to start from an aerodrome, so he wrecked them all. Then he found a wagon and horses on a road and shot both horses. Next he visited a railway station and, as no train was there, he shot the guard on duty and finished up by attacking and stampeding a column of horse transport on the road.

"Still another tackled an aerodrome, circling round at a height of 20 feet, firing into every shed and setting one on fire. A nice two-seater machine was being got out when he arrived, so he wrecked that and used all the rest of the ammunition he could spare flying up and down a railway train full of troops in a siding, firing into it through the roofs and the windows. Another flew up and down the main street of Zonnebeke at a height of 500 feet, firing on troops which were crowded in the street till they had all taken cover. Then he visited a train on a railway siding; then, finding a battery firing, he silenced that and dived on and raided trenches on his way home.

"Another—a youth who has been gaining some notoriety—started by visiting an aerodrome, where he bombed a group of machines on the ground and fired into the sheds. He went off and found a railway siding full of troops waiting for a train, so he scattered them and returned to the aerodrome. One machine was just rising, so he attacked it and it crashed. A second rose from the ground, but he attacked that also, and when it was only 20 feet or so up it side-slipped and likewise crashed. As he left a machine-gun opened fire on him so he went for that and silenced it, and, having done a moderate morning's work, came home.

"These things are only samples selected from a large number of cases, and when you read in an official *communiqué* a brief statement of great air activity with the number of enemy machines destroyed or driven down and the number of ours missing, the thing to recognize is that, even though the balance on those machines is largely in our favor it, it represents but a fraction of our real air victories on that day."—*Aeronautics*.

The Soldier and the Cigarette

THE question whether cigarette-smoking does material harm to health has come into greater prominence now that the habit is almost universal amongst our troops. There can be little doubt that the soldier looks upon the cigarette as part of his kit, as affording him a source of genuine comfort in strenuous times and as increasing the pleasures of relaxation when his nerve-racking duties are for the time in abeyance. Everyone knows that tobacco-smoking has been associated from very remote times with phases of relief from stress and intense activity; the aborigines of America smoked the pipe of peace as much for this cause as to lend gravity to a *pow-wow*. The practice of smoking provides unquestionably a mental anodyne, and that fact alone accounts for its universality in the present bitter days. It must be remembered, however, that tobacco-smoking is a species of drug habit, although perhaps a mild one if we leave out the question of excess, and that the continual drawing of tobacco smoke into the mouth or, worse, deeper into the respiratory tract, introduces toxic risks. Hygienically, of course, air that contains poisonous products of combustion would be condemned as departing from a standard of purity demanded by healthy respiration. Moderate smokers, however, as a rule show no depreciation of normal health. It has been suggested that there may be a relationship between cigarette-smoking and the "soldier's heart." In a careful inquiry into this subject, undertaken at the instance of the Medical Research Committee by Dr. John Parkinson and Dr. Hilmar Koefod, it is concluded that while excessive cigarette-smoking is not the essential cause in most cases of "soldier's heart" it is an important contributory factor in the breathlessness and præcordial pain of many of them. The immediate effect of cigarette-smoking upon the circulatory system and upon the breathlessness of exertion was observed in 30 smokers, of whom 20 were cases of "soldier's heart" and 10 were healthy soldiers. Each subject smoked either four or five cigarettes during a period of 40 minutes. A demonstrable effect was recorded in 17 of the 20 patients, but it is interesting to note that the three unaffected were non-inhalers. Nine of the 10 controls, all inhalers, were influenced in the same fashion, though not to the same degree. Generally the observations show that in health the smoking of a single cigarette by a habitual smoker usually raises the pulse-rate and blood pressure perceptibly; and these effects are a little more pronounced in cases of "soldier's heart." Moreover, the smoking of a few cigarettes can render healthy men more breathless on exertion, as was shown to be the case in a large proportion of the patients under examination. The results show clearly that the soldier should be warned against inhaling, and, of course, he should avoid excess.—*The Lancet*.

Westminster Hall Damaged By Wood Worms

A SPRAYING mixture, composed of cedarwood oil, soft soap, paraffin wax, and certain powerful chemicals compounded by Professor H. Maxwell Lefroy, of the Imperial College of Science and Technology, South Kensington, has been used within the last few days against the woodworm (*xestobium tesselatum*), which has been playing havoc in the roof timbering of Westminster Hall. The insecticide is so powerful that those using it have to wear gas masks. According to Mr. Frank Baines, Architect to the Office of Works, the grub lives only on oak, and it would be possible to bury a man waist deep in some of the holes that it has made in the oak trusses of the Hall. This drastic treatment is a last measure of protection, and at present science can suggest nothing further. The roof has been sprayed several times, and it is confidently expected that the plague will now be stayed. Mr. Baines is of opinion that it has been going on 400 years.

"The Origin and Evolution of Life"

A Review of Professor Henry Fairfield Osborn's Latest Work

THAT the Origin and Evolution of Life are due primarily to the cooperation of *energies* known to the physicist and chemist from their action in the inorganic world; that the material of living beings is captured and adapted, and their forms molded by these energies under the action of the survival of the fittest—this is the thesis developed by Henry Fairfield Osborn in his recently published work* and briefly outlined below.

In tracing the course of evolution the tendency in the past has been to treat it chiefly in those terms of matter and form familiar to the naturalist; but here stress is laid not on the forms of living plants and animals but on the *phenomena of living energy*. The naturalist's point of view is for the time abandoned for that of the physicist, looking not from matter backward into energy but rather from energy forward into matter and form.

As the author is a thorough going evolutionist no arguments are offered for the truth of evolution, now no longer ranked as a theory but admitted as an inevitable natural law, so widely acknowledged that the honor of its interpretation is no longer limited to any single scientist, not even to Darwin who was its greatest exponent.

The subject was developed in the course of preparation of the Hale Lectures before the National Academy of Sciences, the author's part in which occurred midway in a series designed to present the course of cosmic evolution. The preceding lectures on the constitution of matter and the evolution of the elements, of the stars, and of the earth, served to direct the author's attention first to the sources, the adaptation, and the coordination of living energies and then to the interpretation of the evolution of form as molded by these energies. Thus the evolution of life is here interpreted in terms of invisible energy, having long since been written in terms of visible form; and life is viewed as a continuation of the evolutionary process rather than an exception to the rest of the cosmos, and as an embodiment of limitless and ordered energy.

Discussing the various theories of the probable nature and origin of life, the author finds the vitalistic and supernatural interpretations, on the one hand, and the mechanistic and materialistic interpretations, on the other, to be alike unsatisfying. Believing with Emerson that "the laws of Nature are the laws of God and are as binding as the Decalogue" he refuses to interpret life as an arbitrary interruption of those laws, a supernatural interposition by an externally creative power, or as caused by an internal perfecting agency other than the known and unknown physicochemical agencies; nor does he admit an explanation of life as merely a question of matter or mechanism. He thus parts company with Jacques Loeb, the most eminent exponent of the mechanistic school, who in his latest work "The Organism as a Whole" attributes life to the selection or survival of the fittest physicochemical experiments of Nature.

In contradistinction to the vitalistic, mechnistic and materialistic schools of thought we might coin a word and describe the concept of life here developed as "energistic." The *creative* power of energy is well known. In physics energy controls matter and form; in physiology function controls the organ; in animal mechnics motion controls and, in a sense, creates the form of muscles and bones. In every instance some kind of work or energy precedes some kind of form, rendering it *probable* that energy also precedes and controls the evolution of life. It appears reasonable to suppose that when life appeared on the earth some forms of energies pre-existing in the cosmos were brought into relation with the energy properties of the chemical elements also existing. It is a matter of pure speculation whether there is a peculiar vital energy or not. In the author's opinion there is probably no peculiar vital energy, because the researches and experiments of Loeb and other biochemists have thus far revealed no evidence for it.

THE SOURCES OF LIVING ENERGIES

With the advent of life the evolutionary process immediately takes an entirely new direction; the cosmic processes cease to run down and begin to build up, abandoning old forms and constructing new ones, continually giving birth to an infinite variety of new forms and functions which

*The Origin and Evolution of Life by Henry Fairfield Osborn, Charles Scribner's Sons, New York, 1917.

never appeared in the universe before. That this new development of living organisms is nevertheless a true evolution from the older world of lifeless substances may be inferred from the fact that the various energies of heat, of light, of electricity, of chemical reactions, of gravitation, are utilized in both alike, nor has any form of energy been discovered thus far in living substances which is peculiar to them and not derived from the inorganic world.

The adaptation of these various energies to the needs of living organisms is, so far as known, effected through the operation of well-known laws of physics and chemistry; and, since every advance thus far in the quest as to the nature of life has been in the direction of a physicochemical rather than of a vitalistic explanation, it appears
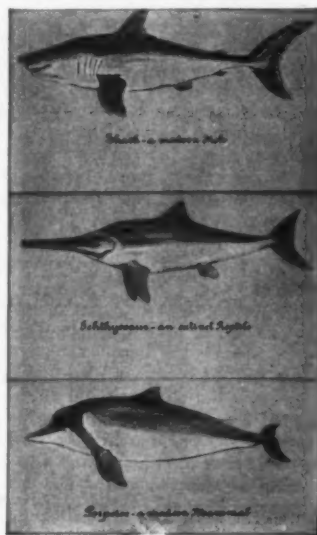

Fig. 1.—Three totally unrelated marine vertebrates

A fish, a reptile, and a mammal—moulded by Evolution and Selection into similar forms adapted to a similar inorganic environment. The 'stream lines' are those of the modern yachts and aeroplanes.

probable that the final solution of the problem—if ever it is attained—will also prove to be physicochemical.

THE THEORY OF ACTION, REACTION, AND INTERACTION OF ENERGY

The theory is advanced that life may ultimately be explained through the threefold phenomena of action, reaction, and interaction. In the domain of physiology the laws of physics governing action and reaction and the transformation and degradation of energy are known to be of prime importance in effecting that capture of energies so essential to every living organism. For instance, the heat, light, and chemical energy of the sun are transformed into the chemical potential energy of the compounds of carbon, hydrogen and oxygen in the plant, transmuted by the animal into motion and heat, and then dissipated. Thus in the life cycle we observe both the conservation and the degradation of energy, corresponding with the first and second laws of thermodynamics developed in physics by the researches of Newton, Helmholtz, Phillips, Kelvin and others.

Although these two great principles that the energy of motion can be converted into an equivalent amount of heat, and that a certain amount of heat can be converted into a more limited amount of power were discovered through observations of larger masses of matter, they are believed to apply equally to such motions as those of the smallest electrically charged atoms (ions) and the particles flying off in radiant energy as phosphorescence. Such movements of infinitesimal particles underlie all the physicochemical laws of action and reaction which have been observed to occur within living beings.

The most striking feature of the author's concept comes in at this point, namely, that the coordination and harmonizing of all the several parts of a living plant or animal is brought about through the evolution of a physicochemical principle termed "interaction." While actions and reactions, as is well known, refer chiefly to what is going on between parts of an organism which are in chemical or physical contact, interactions refer to what is going on between parts which are connected with each other by other parts, and cannot be analyzed by dynamical principles alone without a knowledge of the connecting structure. As stated by M. I. Pupin, action and reaction are chiefly simultaneous, whereas interaction connects actions and reactions which are not simultaneous; to use a simple illustration: when one pulls at the reins the horse feels it a little later than the moment at which the reins are pulled—there is interaction between the hand and the horse's mouth, the reins being the interacting part. Again, in interaction the cause may be very feeble, yet the potential or stored energy liberated at a distant point may be tremendous. An interacting nerve-impulse starting from a microscopic cell in the brain may give rise to a powerful muscular action and reaction at some distant point. An interacting chemical impulse may energize or depress whole groups of organs in animals and plants.

The central theory developed in this speculation on the Origin of Life is that physicochemical action and reaction concerned in the transformation, conservation, and dissipation of energy, produces also, either as a direct result or as a by-product, a physicochemical agent of some kind of interaction which permeates and affects the organism as a whole or affects only some special part—in brief, some sort of "chemical messenger," to borrow the term of Starling and Bayliss. Among the first of these interacting agents to be discovered are the so-called "enzymes." Through such interactions the organism is made a unit and acts as one, because the activities of all its parts are related, balanced, and well timed.

It is but a step to extend the principle and suppose that all actions and reactions are similarly coordinated: and that while there was an evolution of action and reaction—as in breathing, nutrition, muscular action, sensation, and motion of all kinds—there was also a corresponding evolution of interaction, for without this the organism would not evolve harmoniously. It is a further step to imagine that the directing power of heredity which regulates the initial and all the subsequent steps of development in action and reaction may have been also an elaboration of the principle of interaction.

The actions, reactions and interactions of living organisms and the coordination of their activities are largely dependent upon the two physicochemical phenomena known as *ionization* and *catalysis*. Ionization is probably the chief agent of action and reaction, while catalysis is the chief agent of interaction.

Ionization, discovered by Arrhenius, is an electric property of the chemical elements. Ions are atoms or groups of atoms carrying electric charges which are positive when given off from metallic elements and negative when given off from non-metallic elements, and this form of electric energy in the chemical "life elements" is a matter of prime importance in the evolution of life. With the single exception of hydrogen, all the great structural "life elements" which make up the bulk of plant and animal tissues are of the non-metallic group, while the lesser components of living compounds are such metallic elements as potassium,

2.—The Giraffe

Fig. 3.—Okapi

Two closely related animals (belonging to the giraffe family) moulded by Evolution and Selection into unlike forms adapted to their differing environments. In arid regions where food is scarce the giraffe with its towering height can browse on branches and tree-tops inaccessible to other animals; whereas the more deerlike okapi in the tropical rain-forests can find an abundance of food in the luxuriant undergrowth

sodium, calcium and magnesium. In general the electric actions and reactions of the non-metallic and the metallic elements dissolved or suspended in water are now believed to be among the chief phenomena of the internal functions of organisms. For instance, the ions of hydrogen are very important factors in animal respiration and in gastric digestion.

THE CHEMICAL MESSENGERS OF INTERACTION

The chemical principle of catalysis is proving to be of the utmost importance in the life processes as a means of coordinating the chemical activities of one region of an organism with those of all other regions. A catalyzer is a substance which modifies the velocity of any chemical reaction without itself being used up by the reaction. Discovered as a property in the lifeless world, catalysis has proved to underlie the great series of functions in the life world which may be comprised in the physical term interaction. The researches of Ehrlich and others begin to justify Huxley's prediction of 1881 that it might become possible "to introduce into the economy a molecular mechanism which, like a cunningly contrived torpedo, shall find its way to some particular group of living elements and cause an explosion among them, leaving the rest untouched." In fact, the interacting agents discovered by physiologists and known as "enzymes" are such living catalyzers, because they accelerate or retard reactions in the body by forming intermediary unstable compounds which rapidly decompose, leaving the catalyzer free to repeat the action.

Other interacting agents are those known as internal secretions, due for the most part to the so-called ductless glands, like the thyroid, which liberate some substance within their cells that passes directly into the blood and has a stimulating or inhibiting effect upon other organs. With the discovery that the regulating and balancing functions, as well as the accelerating or retarding of the activities of certain parts of organisms, are phenomena of physicochemical interaction in individual development, we obtain a glimpse of the possible causes of the balance, development, or degeneration of certain parts of plants and animals through successive generations. In fact, a heredity hypothesis was proposed by Cunningham based upon Berthold's discovery that the connection between the germ-cells and the secondary sexual characters of fowls was really of a chemical rather than of a nervous nature as had previously been supposed. Here is where a great amount of ingenious experimentation must be done to ascertain whether these chemical messengers influence the heredity-germ as well as the body.

THE CHEMICAL LIFE ELEMENTS

Of the 29 or more chemical elements known to occur in living organisms either invariably, frequently, or rarely, those essential to all forms of life are the following:

Hydrogen, the life element of least atomic weight, present in all acids and in most organic compounds; *Oxygen*, forming two-thirds of all animal tissue and one-half of the earth's crust, with an attractive power, like hydrogen, of bringing into the organism other elements useful in its various functions; *Nitrogen* third in importance as structural material; *Carbon* so dominant in living matter that biochemistry is very largely the chemistry of carbon compounds; *Phosphorous*, essential in the nucleus of the cell (being a large constituent of chromatin which is the seat of heredity) entering largely into the structure of nerves and brain, and serving as building material for the skeletons of animals; *Sulphur*, essential in proteins; *Potassium*, on which the activity of chlorophyll depends; *Magnesium*, essential to chlorophyll; *Calcium*, important as a constituent of animal skeletons; and *Iron*, essential to protoplasm, present in chlorophyll.

THE ORIGIN OF LIFE

Always remembering that as yet the mode of the origin of life is a matter of pure speculation, it is clear that the evolution of living organisms from lifeless matter must have included among other processes the assemblage, adaptation, and coordination of energies from all these sources; and we may imagine the origin of life as probably a gradual evolution, marked by short leaps or accessions of physicochemical energy, and not as a sudden revolutionary change in nature.

One of the earliest steps in the organization of living matter may have been the assemblage one by one of

Fig. 4.—Bulk of the Heredity—chromatin in the germ-cells of the *Sequoia* and the Trinity-flower, *Trillium*.

Chromatin rods in an embryonic cell of the *Sequoia* compared with those in an embryonic cell of the small wood-plant known as the Trinity-flower (*Trillium*). The chromatin of *Sequoia* (Sc.), which contains all the characters, potential and casual, of the giant tree, is less in bulk than the chromatin of *Trillium* (Tc.).

S. *Sequoia washingtonia*, or *gigantea*, the Big Tree of California. The tree known as "General Sherman," shown here, is 279⅗ feet high above ground, its largest circumference is 102⅓ feet, and its diameter is 36½ feet.

Sc. Part of the germ cell of the nearly allied species, *Sequoia sempervirens*, the redwood, with the darkly stained chromatin rods in the centre. About 1,000 times actual size. The redwood is but little inferior in size to the "Big Tree." After Goodspeed.

T. *Trillium*.

Tc. Part of the germ cell of *Trillium sessile*, showing the darkly stained chromatin rods in the same phase and with the same magnification as in the cell of *Sequoia*. After Goodspeed.
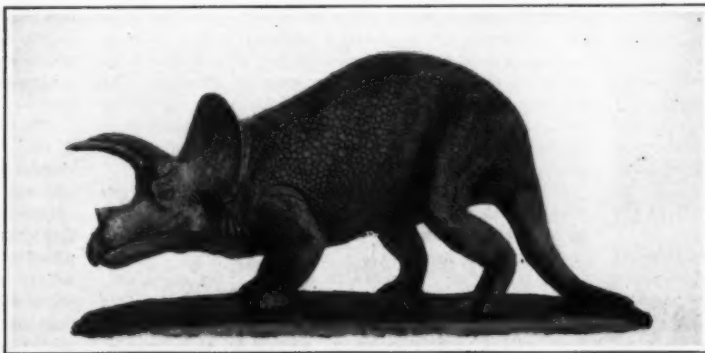

Fig. 5.—The Triceratops, an herbivorous mechanism

Interpreted as a defensive energy complex in contrast with the Tyrannosaurus, shown on the first page

several of the ten elements now essential to life. Of these the four most important—oxygen, hydrogen, nitrogen and carbon—could be obtained from water, air, carbon dioxide, and volcanic emanations, while the remaining six would be derived from the earth. Then in some manner these elements were gradually bound together by a form of mutual attraction which established a new harmonious unit in the cosmos quite distinct from any aggregation of inorganic matter, namely, a living *organism* or *individual*. This union of "life elements" onto a living organism probably occurred in the gelatinous state known to chemists as "colloidal" because all living cells are colloidal in nature, and it is in this state that the elements best display their incessant action and reaction. The evolution and specialization of the various "chemical messengers" referred to above proceeded step by step with the evolution of plant and animal functions. During this assemblage, mutual attraction, colloidal condition, and chemical coordination, there doubtless arose the rudiments of competition and Natural Selection which tested all the actions, re-actions, and interactions of various individuals and secured the survival of the fittest. Finally as the two original and most distinctive features of life there were developed the synthesis of new chemical compounds, now known as the organic compounds, and the continuity of reproduction or heredity.

From the very beginning Darwin's law of Natural Selection—which is not a form of energy but an arbiter between different energies—may have been working to effect the survival of the fittest and the elimination of the unfit through competition between various kinds of organisms, between organisms of the same kind, between the forms and functions of organisms as a whole, and between their separate actions, reactions, and interactions.

Thus we arrive at a conception of the relations of organisms to each other and to their environment as of an enormous and always increasing complexity, sustained through the interchange of energy. (Figs. 1, 2 and 3.)

THE HEREDITY-GERM

The idea that the Heredity-germ is an energy complex is an as yet wholly unproved hypothesis. While its physicochemical nature is assumed by all biochemists, the way is open for the discovery in the germ of some new chemical element or of some distinctive form of energy. In general we know of no analogy to the phenomena of heredity; they are unique in nature, although in some respects they suggest the phenomena of latent or potential energy. If there be any peculiar chemical element or energy in the germ, we may imagine that such energy of heredity, like that of radium, is very great per unit of mass of the matter which contains it; but, unlike that of radium, is in process of accumulation, construction, conservation, rather than of dissipation and destruction. Such hypothetic germ energy is not only cumulative but is in a sense imperishable, self-perpetuating, and continuous during the whole period of the evolution of life upon the earth.

After years of study and experiment scientists have now determined that the material or visible seat of heredity in the germ is a substance called *chromatin* contained in the reproductive cells, and distributed to every cell in the body. The chemical constitution of this chromatin must infinitely exceed in complexity that of any other form of matter or energy known. It would appear possible, therefore, according to the modern interpretation of students of the cell and of biochemistry, that the continuity of life since it first appeared is the continuity of the physicochemical energies of the chromatin; the development of individual life is an unfolding of energies taken into the body under the directing agency of the chromatin and the evolution of life is essentially the evolution of the energies of chromatin. But while we know the chromatin to be the physical basis of inheritance, we cannot form the slightest conception of the mode in which a speck of chromatin in the reproductive cell controls, for instance, the destinies of the Big Tree, *Sequoia gigantea*, and lays down all the laws of its being for its long life period of 5,000 years. Fig. 4.

ENERGY AND FORM

It would seem that the chief end of life is energy—the first efforts of life, the earliest adaptations we know of, are designed for the capture, the storage, the release of energy; and the highest and most complex forms of life are merely successful specializations toward the same end. A few bacteria, considered among the most

primitive organisms now existing, derive their energy—as the earliest forms of life must have derived it—from inorganic chemical compounds; but in general living organisms depend upon other living organisms for their food-supply, and the object in life of each organism is to find something to eat and to escape being eaten.

In the simplest organisms energy or food may be captured while the organism as a whole is in a state of rest; but soon special organs of locomotion are evolved by which energy is sought out, and organs of prehension by which it may be seized. Along with these motor organs are developed organs of offense and defense of many kinds, by means of which stored energy is protected from capture or invasion by other organisms. Finally, there is the most mysterious process of all by which these manifold modes of energy are reproduced in successive generations.

Thus the organism as an arena for energy acting upon matter becomes in a measure conceivable, and we may trace the course of the evolution of form from that stage of relative simplicity represented in the single-celled animals up to the inconceivable complexity of energy and form that highly evolved organisms, such as the large reptiles and mammals and man, present to the eye of the anatomist and physiologist. (See frontispiece and Fig. 5.)

The energy conception of the origin and evolution of life is as yet in its infancy, and the difference between the lifeless and the living world seems like a vast chasm when we think of a very high organism like man, the result of perhaps a hundred million years of evolution. But the difference between primordial earth, water, and atmosphere and the lowliest known organisms which secure their energy directly from simple chemical compounds is not so vast a chasm that we need despair of bridging it some day by solving at least one problem as to the actual nature of life—namely, whether it is solely physicochemical in its energies, or whether it includes a *plus* energy or element which may have distinguished LIFE from the beginning. To the solution of this question the unremitting experiment of the biochemist, physicist, and biologist working hand in hand must be directed.

Damage from Soil Fungi

A CONSIDERABLE amount of damage has been noted during the past season among various plants of the Garden, apparently caused by the presence of fungi which normally inhabit the humus of the soil. The fungi constitute a large group of micro-organisms which either live as saprophytes on dead matter or as parasites on living animals or plants. In the past it has been customary to regard a few fungi as being the cause of plant diseases, while a vast majority were considered innocent saprophytes merely living as scavengers on dead and decaying matter. Opinion, however, has gradually changed, until at the present time a vast number of fungi which have formerly been considered harmless are found under favorable conditions to be virulent parasites, causing an immense amount of damage to cultivated plants. In fact, some biologists are inclined to regard the depletion in the fertility of soils under constant cultivation very largely to the presence of this type of microorganisms, and to look for a remedy for this condition to some carefully worked out method of sanitation by which the soil can be rid of these harmful organisms.

The attention of the writer has recently been called to a bed of Funkias in our grounds in which about one-third of the foliage had been killed. The examination of the leaves of these plants, while showing slight traces of fungus mycelium and spores, as is usual on dead plant tissues, did not reveal any particular species present in sufficient abundance to account for the death of the plants.

A careful examination of the soil about the bases of these plants, however, showed the presence of a fungus belonging to the genus *Sclerotium*, which had apparently attacked the plants through the medium of the soil, causing the base of the large leaves to rot entirely off in some cases and in this way accounting for their death. While difficult to determine with any degree of certainty, the fungus appeared to be *Sclerotium Semen* Tode, a species which commonly occurs on dead leaves and in the humus of the soil. The species receives its name from the fact that the only fruit produced is a sclerotium resembling in form and color grains of mustard seed, although often very much larger. While usually regarded as a saprophyte, from the above observations, this fungus has shown its ability under favorable conditions to attack living plants, causing their death.

Further search revealed the fact that this fungus was not restricted to the one host on which it was originally detected, but attacked other plants as well, causing a large amount of damage. A strictly parasitic fungus is often very selective in its habits, restricting its attacks

to a certain species or to a number of very closely related species of plants. These semi-saprophytic species, on the other hand, are often less selective and often quite omnivorous in their habits and for this reason more difficult to control. Apparently the only successful means of combating these and other similar types of fungi is to work out some method of soil treatment which will enable us to attack the fungis at its source of infection.

Earlier in the season the attention of the winter had been called to the presence of a fungus on the bulbs of the garden tulip which appeared to be accountable for the failure of the plants produced from such bulbs to bloom. This fungus belonged to the same genus as the preceding, and although the species has, so far as known, not been mentioned in American literature it occurs in Europe, where it has caused great losses among professional tulip growers. While the origin of infection of the latter, *Sclerotium Tulipae* Therry, is not known with certainty, we have reason to suspect that it is the same as that of the preceding species.

Still another fungus which has ordinarily passed as a saprophyte has been found to attack the rootstocks of the wild geranium, causing their decay. Laboratory experiments have been carried on with the latter species in order to determine its life history and habits and the results of these experiments will be published in the near future.

In addition to the few cases which have come under observation during the past season, a large number of the diseases of cultivated plants are now known to be caused by similar fungi which are transmitted through the soil. The soil is no longer regarded as made up entirely of inert matter, but is now known to be teeming with life, and one of the largest problems confronting the biologist today is to determine the nature and effect of these minute organisms on growing vegetation.—F. J. SEAVER in the *Journal of the N. Y. Botanical Garden.*

Indigenous Indian Dyes

THE recent crisis in the dyeing trade, consequent upon the stoppage of the supply of German dye-stuffs, lends special interest to an article on "The Dyeing Values of Some Indigenous Dye-Stuffs," by Mr. J. P. Srivaslava, M.Sc., of the *Agricultural Journal of India.* The article summarizes the results of an investigation into the dyeing values of certain natural coloring materials as follows:

(1) Harsinghar (*Nyctanthes arbortristis*). The flowers of this tree contain a beautiful yellow coloring matter, which is soluble in water and alcohol. It gives brilliant yellow shades with all mordants on wool, while on wood mordanted with bichrome and oxalic acid before dyeing a beautiful brown is obtained.

(2) Tun (*Cedrela toona*). This tree occurs frequently in the sub-Himalayan forests. The flowers, which contain a yellow coloring matter, are dried and sold. A good shade is obtained on wool, but the dyeings are not very fast to milling with soap and soda.

(3) Tesu or Dhak (*Butea frondosa*). The flowers of this tree, which grows abundantly all over the United Provinces, contain a yellow coloring matter. The dyes on wool vary from brown to dull crimson, according to the mordant used, and are fairly fast to milling.

(4) Haldi or Turmeric (*Curcuma longa*). This is a dried rhizome or tuber, and a well-known constituent of curry powder. It contains a brilliant yellow coloring matter, which, however, possesses the serious drawback of being changed into red by soap or alkalies. The coloring matter, called *curcumin*, is sparingly soluble in cold water, more freely in hot water, and completely in alcohol. On wool the best shade is obtained on chrome mordant, and the fastness is fair.

(5) Arusa (*Adhatoda vasica*). This is an ever-green plant, which grows in the United Provinces. The leaves yield a yellow coloring matter, *arusa*, which is soluble in water and also in alcohol.

(6) Naspal or Pomegranate Rind (*Punica granatum*). The rind contains a tanning substance and also a yellow coloring matter, which dyes very good shades varying from yellow to full brown on wool. All these possess very good fastness to milling.

(7) Jangli Nil or Wild Indigo (*Tephrosia purpurea*). This is a small woody annual, occurring abundantly in the United Provinces. Its name is due to its similarity to the indigo plant, but it does not contain any substance yielding indigo. The coloring principle is allied to quercetin. Owing to the difficulty of separating the yellow principle from the chlorophyl, efforts to secure a pure yellow have only been partly successful, but the coloring matter is of great value, as it yields dyeings which are comparatively fast to light, washing, and milling.

(8) Safflower, or Kusum (*Carthamus tinctorius*). The dried flowers of this plant contain a coloring matter which before the introduction of coal-tar colors was highly prized all over the world. It produces on cotton beautiful shades of red, varying from a full crimson to the most

delicate pink. Safflower contains two distinct coloring matters: (1) a yellow, soluble in water, which is by far the larger constituent, and (2) a red, which only occurs in small quantities, but is the more valuable of the two. It seems that the Egyptians at an early period were acquainted with the safflower yellow dye.

(9) Majith (*Rubia cardifolia*). The root and twigs of this plant contain a dye-stuff identical with madder. It was largely used in India before the advent of synthetic alizarine, but its cultivation has ceased, although it is once again in great demand. It is undoubtedly one of the most valuable indigenous dye-stuffs. With its help, maroon and bordeaux shades of excellent fastness to light can be dyed on all fibres. It is the basis of a great many colors required by calico-printers.

(10) Cutch or Katha (*Acacia catechu*). This tree is found in several parts of India. An extract made by boiling the wood in water is still largely used in dyeing. Catechu is exported to Europe for use both in dyeing and tanning. It may be applied to all fibers, though it is most largely used on cotton. Catechu brown is one of the fastest colors known.

(11) Patang or Sappan Wood (*Caesalpinia sappan*). This is a variety of the so-called Brazil wood, which was once very largely used for dyeing in Europe. The coloring principle, *brazilein*, exists in a colorless condition in the freshly-cut wood, and is by oxidation converted into the true coloring matter. The wood is similar in its composition to logwood. Patang is a valuable color-yielding material, and produces brilliant shades of red, crimson and purple.

(12) Lac dye is still manufactured largely in certain parts of India, though it has lost much of its former importance. It yields beautiful scarlet and crimson shades.

(13) Indigo. The uses of this most valuable dye are too well known to be described in this short article.

(14) Kachnar (*Bauhinia racemosa*). The bark of this shrub yields a coloring matter which is employed for dyeing dull reds on cotton, on which it may be used without any mordant. It is also said to be used in Burma for obtaining a dull black on cotton. In this case it is dyed direct in an infusion of the bark, and is then worked in mud whereby the dull red is changed to black. The bark can be had in any quantity, and may be of service to tent manufacturers who require a dull red color for the inside of tents.

(15) Peepul (*Ficus religiosa*). The roots of this contain a red dye, which gives a good pink on cotton mordanted with alumina. The shade so obtained is fairly fast.

(16) Red Sanderswood (*Pterocarpus santalinus*). The wood of this tree yields a valuable red dye, which was largely employed before the advent of synthetic dyes. It can be used on wool without any mordant, while very good shades of satisfactory fastness are obtained on cotton with tin and alumina mordants.

(17) Roli or Kamela Powder (*Mallotus philippinensis*). This dye is obtained from a small tree found along the foot of the Himalayas and in Southern India. It used to be largely employed for dyeing silk, on which, with alumina mordant, it gives a beautiful yellow.

(18) Akhrot (*Juglans regia*). The bark yields a valuable brown dye, which is of special importance for wool at the present moment, because on this fiber it gives a fast shade that may easily be modified to a khaki.

(19) Kathal (*Artocarpus integrifolia*). The wood yields a yellow coloring matter which may be dyed on cotton on alumina mordant. The shades are good and fast.

(20) Barberry (*Raswat*). The bark, roots, and stem of this plant are rich in a very good yellow dye, which is chiefly used for silk. The dye principle is berberine, an alkaloid containing nitrogen.

(21) *Rhus cotinus*. The wood of this plant yields a dye similar to young fustic. On cotton mordanted with alumina an orange yellow was obtained; with tin, an orange red. The dyeings, however, are not fast to alkalies and soap.

It may be interesting to compare the foregoing list with the list of dyes commonly used by English dyers in the eighteenth century. These were nearly all vegetable. "The principal were logwood, fustic (from the *Maclura tinctoria*); Brazil-wood (*Caesalpinia brasiliensis*); madder, woad, Indico, made of a weed of the same nature with woad; woodwax (*Genista tinctoria*, or greenweed); wild (*Reseda lupeola*, or dyer's mignonette) and arnotto. Cochineal was another important dye. The mineral ingredients include arsenic, verdigris, and copperas (ferrous sulphate), which was used with oak galls for making a black dye . . . Then there were what were really mordants, though the principle of their action was unknown. Chief of them was alum . . . but aquafortis impregnated with pewter, which would seem to provide a solution of impure lead and tin nitrates, is also mentioned, and so are saltpeter and argol (bitartrate of potash.)—*Journal of the Royal Society of Arts.*

The Speed of Ships[*]
Determining Conditions

IN comparing the speeds of ships a number of factors must be taken into consideration if the comparison is to be just. Thus to the lay mind it seems surprising that small warships like torpedo-boat destroyers should possess such remarkable speeds as compared with merchant vessels. Years ago it was thought that there was an absolute limit to the speed of a ship, which depended upon her length, and that no matter how much power was put into her it would not be possible to exceed this speed. There is, of course, a limit to the speed of any particular ship, but it depends only on the maximum amount of power that can be put into the vessel.

WARSHIPS

Vessels of war and merchant ships are given speeds suitable for the special work they have to perform. An interesting illustration is given by an examination of the different types of warships. In any vessel there is a definite weight, made up of various items, which must not be exceeded. It includes the weight of hull and fittings, machinery, armour, armament, fuel and stores. It is, however, within certain limits, in the hands of the designer how he shall allocate these weights. In torpedo-boat destroyers it is possible to keep the weight of hull comparatively small since the nature of their work does not demand heavy scantlings. Armour is entirely absent, and the armament quite small. In consequence there is a good deal of weight available for the machinery which means that great power can be put into the boat and a high speed obtained. In light cruisers different considerations obtain. The speed is sacrificed somewhat so that the machinery weighs relatively less, leaving more weight available for light armor and for heavier armament than the destroyer possesses. This result is not achieved, however, without making the cruiser larger than the destroyer. Larger ships can be driven at the same speed as smaller ones with relatively less power in the machinery, so that in a cruiser there is an appreciable weight left for the armor and armament.

This principle of the easier attainment of speed with increase of size is followed through into battle cruisers. These vessels require heavy armament and moderately heavy armor, but in addition they must have good speed. The result is that they become very large vessels, their length being particularly great as it is the most important factor in the easy attainment of high speed. In the battleship high speed is not considered of such great importance, but both armor and armament must be heavy. The speed, however, is sacrificed to such an extent that it becomes possible to build battleships of smaller lengths than battle-cruisers. In other words, the armor in the battle-cruiser is not sacrificed to such an extent as to enable the necessary speed to be obtained on the same length as that of a battleship.

MERCHANT SHIPS

What has been said for warships is also true in principle for merchant vessels, although in the latter the items affecting the argument are different. In the slow-moving cargo ship the object is to carry as much cargo as possible. As a result the speed is kept low so that the weight of the machinery is small and the vessel can be made with full under-water form, thus ensuring that the maximum weight of cargo will be carried. In the intermediate type, that is, the vessel carrying a few passengers, it is desirable on their account that the vessel should move more quickly than the purely cargo boat. To obtain this greater speed cargo weight is always sacrificed by the heavier weight of machinery carried and generally by making the under-water form finer than in the cargo ship. In the ocean liner, which must carry its passengers at a speed greater than in the intermediate type, the size of the vessel is increased in order that the higher speed may be more easily obtained, and in addition the under-water form is made still finer so that for this reason and on account of the great weight of the machinery comparatively little cargo is carried. In fast passenger channel steamers practically everything is sacrificed to speed, and in this respect they are somewhat similar to torpedo-boat destroyers. Although these vessels are given comparatively high speeds, their size is limited by harbor accommodation and the fact that the number of passengers traveling may not be sufficient to fill them completely. They carry little or no cargo, practically all the available weight apart from the weight of hull, fittings, and passengers being used for machinery.

LIMITING SPEEDS

It might be thought that by the installation of very powerful, although heavy, machinery it would be possible to obtain practically any speed. In this connection an interesting point arises. If the under-water form of a ship is made very fine it follows that her total weight or displacement will be small, and although she will be easy to drive on account of her fineness of form there will be very little weight available for the machinery, so much so that she may not be able to carry the machinery necessary to drive her at a particular speed. If the under-water form is now made fuller, although she will be more difficult to drive at the same speed, there will be much more weight available for the machinery and sufficient power can be installed to obtain the desired speed.

If the process of filling out the under-water form and installing heavier machinery is continued a time will come when the increased weight of machinery required for the given speed is greater than the increase in the weight available in the ship. In other words the under-water form of a ship may be so full that it is impossible to make the machinery heavy enough to generate the power required to drive her at the given speed. What actually happens thus is that there is some minimum and maximum limit to the fineness or fullness of the under-water form below or above which there is not enough weight available for the installation of machinery sufficiently powerful to drive the vessel at the given speed. Between these two points it is possible to install machinery which will not only be powerful enough to drive the vessel at the given speed, but will also leave a margin of weight for other purposes, and at some point more or less midway between them this margin of weight will have a maximum. If a ship is properly designed for her particular purpose so that she is of the minimum size to obtain the desired speed the minimum and maximum degrees of fullness of under-water form will come together, and this is the condition that should be aimed at in the design of fast vessels. Such a speed can then be truly described as the limiting speed of the ship, since no fining of the under-water form or increase in weight of machinery will increase the speed.

WEIGHT OF MACHINERY

It is fairly obvious that the more horse-power is obtainable from a ton weight of machinery the greater the speed that can be given to any ship, and in this way the limiting speed of a vessel can be increased. Enormous strides have been made in this direction since the days of the early reciprocating engine. The great increase in the speed of torpedo-boat destroyers is almost entirely due to such improvements. Water-tube boilers generate much more steam per ton of weight than cylindrical boilers, and their introduction allows more power to be obtained in a given ship. Turbines are also lighter than reciprocating engines and have the same effect. Twenty years ago the attainment of a speed of 20 knots in a channel steamer 300 feet long was a remarkable achievement. Some few years ago, however, a speed of 25 knots was obtained on a similar vessel of the same length. The first ship was fitted with triple-expansion engines and tank boilers, while the latter had geared turbines and water-tube boilers. After the war when new channel steamers will be built something even better may be expected, since double-reduction geared turbines will almost certainly be fitted. These are lighter than the single-geared turbines. In addition, should the supply of oil fuel become assured and its price reasonable, its adoption would render the attainment of still greater speeds possible. Oil fuel generates steam more efficiently than coal, thus reducing the weight of the boilers. A smaller weight of it needs to be carried to give the same steaming radius as coal. The load of the ship is therefore, less, leaving more weight available for machinery, by which a further increase of speed can be obtained. Another advantage of light machinery is that greater increase of speed which increase of length can be obtained.

The fitting of light machinery has an important commercial application. The lighter the machinery the less the power required to attain a certain speed in a given ship. In consequence the fuel consumption is less. But in spite of this fact the lightest form of machinery is not generally adopted in merchant vessels, the reason being apparently that shipowners consider that the reliability is not so great as with the heavier type. This consideration applies more particularly to boilers, although for the same reason turbines have not been taken up as rapidly as they might have been. The latter, however, are now making rapid headway. With regard to the former, although water-tube boilers are fitted in all war-ships, they are still considered to be unreliable in the merchant service. They have, however, been used, especially in channel steamers, with success, and some American owners speak highly of their reliability.

MAXIMUM SPEEDS

It is doubtful if there is any limit to the speed of a ship if everything else is sacrificed to obtain it. Reference has already been made to the greater speeds obtainable in large ships. Disappointment is often expressed over the small speed of large vessels, both of the Navy and the mercantile marine. The reason has been given for this in war vessels, and in merchant ships it would not be profitable to run at great speeds. It would be quite possible to build a ship to travel at, say, 70 miles an hour, that is, at the speed of a railway train. Needless to say she would have to be of great length, over 1,000 feet, and everything in the way of weight would have to be sacrificed. She would in fact be something like a torpedo-boat destroyer magnified enormously. Small models of ships have, of course, been run in experimental tanks at speeds, which if reproduced proportionately in actual ships would be even greater than that mentioned above. If, however, ships could be made large enough to carry the necessary machinery these speeds could be obtained. The lighter the machinery can be built the smaller can the ship be made to attain these great speeds. Theoretically, therefore, there is no limit to the speed of ships, but practical politics fixes one. The late W. Froude estimated the horse-power required for a special type of ship of 2,500 tons displacement. The maximum speed he calculated for was no less than 130 knots with a horse-power of about 1,000,000. Needless to say such a small ship could not carry the machinery to generate this power.

At the present time speeds of 45 miles an hour have been obtained, and improvements in machinery will increase this value. There is no reason to suppose that these improvements will not take place. This much is certain, that if oil engines could be built to give the large powers required in high-speed ships a distinct advance in speed would at once be brought about. The future is bound to see an increase in the speed of ships.

Anthropologists Examine Pitcairn Islanders

WHEN Mr. and Mrs. Routledge finished their investigations on Easter Island in 1915, they touched at Pitcairn Island, and there engaged two brothers, direct descendants of the "Bounty" mutineers, Charles Young, aged 28, and Edwin Young, aged 25, to serve as hands on their yacht "Mana". On their arrival in England these young men were sent to the Royal College of Surgeons to undergo examination by Prof. A. Keith and Dr. W. Colin Mackenzie. This is the first opportunity enjoyed by European anthropologists of examining members of this interesting community. From their report, published in the August issue of *Man*, it appears from examination of their genealogy that their ancestral composition should be 13/32 parts British and 19/32 parts Tahitian: Prof. Keith sums up the result of the examination as follows: "I regard the two Pitcairn Islanders as decidely more Tahitian than European in their physical characteristics. In facial features Charles is European, Edwin is not, yet in actual shape of the head the case is reversed—Charles has the typical Tahitian head, Edwin rather the European; in texture of hair they are Tahitian rather than European. In size of brain they are typical of neither British nor Tahitian, but incline rather to the second than to the first. But there can be no question of physical degeneration; they are both splendidly developed men." They belong to the sixth generation of the descendants of the mutineers—six generations in 127 years.—*Nature*.

## Elastic Peculiarities of Phosphor-Bronze Wires

PREVIOUS experiments on platinum-iridium [see *Science Abstracts* 10 (1911) and 147 (1913)] suspension wires showed some complicated relations between the period of vibration and the amplitude of swing. The present paper describes the results of similar experiments on 13 phosphor-bronze drawn wires of diams. ranging from 0.100 to 0.508 mm. It was found that, as before, a larger amplitude gives a greater period of swing, though to a less extent than is the case with Pt-Ir. The actual results are exhibited graphically in the paper, and it is seen that the effect of drawing the wires is to make the departure from the ideal elastic solid increase steadily with the increased fineness of the drawn wire. A new effect, which might be classed as a second order of effect, superimposed on the one noted above, has been discovered. This effect is the increase in period with decreasing amplitude after a certain limiting amplitude has been reached.—Note in *Science Abstracts* on a paper by L. P. SIEG and A. J. OEHLER, *Acad. Sci., Iowa. Proc.*

[*] The *London Times Engineering Supplement*.

Photos by The Gilliams Service

The Braille system of stamping characters
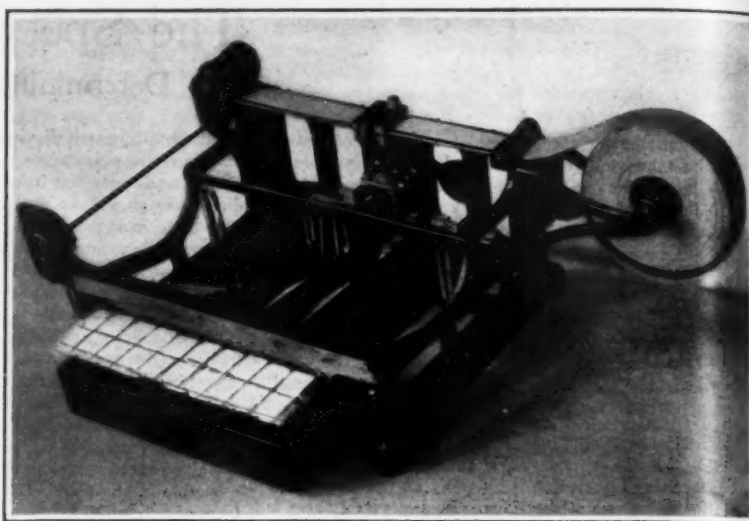
Professor Villey's stenographic machine

Stenographic Machines for the Blind
That Enable Them to Write and Read

THE already very large and constantly increasing number of soldiers in Europe who have been deprived of their sight through wounds or other battle misfortunes in the present great war has aroused considerable interest in means and methods whereby they may be restored as useful wage earning-members of the community.

A number of French inventors have been working on this subject for some time and several of them have recently put forward new and very helpful mechanical devices which enable blind men to take short hand or stenographic records of spoken discourse and reproduce the same in readable form either in the conventional raised letters for the blind, or what is more efficient and helpful to the ex-soldier, in practical business, in ordinary typewriting.

In modern use there are two kinds of typewriters for the blind; those that write ordinary characters and those that write the Braille alphabet. The only modification characteristic of the first class consists in providing keys with characters in relief instead of merely marked, but for typists who can see and practice the touch method the marking of the keys is of little or no importance as they are able to operate with closed eyes if they desire. Where a blind man writes for a fellow blind man the machine must have keys engraved in Braille characters, and the records must be made directly in relief. Of course since there are only six elements of a sign in the Braille alphabet it is perfectly feasible to construct a writing machine that needs only six keys and typebars or punches, with mechanism to provide for the suitable combination of the points, for spacing, and for advancing the paper, shifting the lines, etc. In fact a number of very efficient machines along these lines have been constructed and numerous improvements have taken place just as in the case of ordinary typewriters.

These machines while they employ only a limited number of points write in longhand, as it were, and must be distinguished from the stenographic machines which have been devised for blind shorthand writers. In these the operator must separate the spoken word, not into its letters, but into its constituent sounds and then rely upon a mechanical device which he operates with his fingers to secure a permanent record which he must then transcribe either in Braille writing, or what is of more economic value in the usual characters of the ordinary writing machine.

One of the most interesting and important of the new stenographic machines for the blind is that invented by M. Pierre Villey, a professor in the University of Caen, who has been himself blind since childhood.

Shortly after the breaking out of the war, when large numbers of blind soldiers were invalided home, he appreciated their great need for mechanical help to enable them to make a living. So he set to work on the machine which he has but recently fully developed.

He adopted arbitrary signs for the spoken syllables, and then using a considerable number of points, he divided the signs thus formed into three groups corresponding to the three elements making up the sound of each syllable. These were the initial consonant, the vowel, and the final consonant. In order to make the matter clear, let us assume as the basis of this method of rep-

presenting the sound of a single syllable, a conventional arrangement of 12 points. Divide this into three groups, first reserving five points to signify the initial consonant sounds in the great number of possible combinations. Then five points are taken for the second group of vowels, leaving two points for the third division of the final consonants, which in French, at any rate, are comparatively unimportant.

The five points may be arranged in 31 different ways, and such conventional symbols may be assigned to 31 initial consonants or groups of consonants (pl, tr, etc.,) to 31 vowels or groups of vowels, and lastly three combinations of the final consonants. Now with a machine
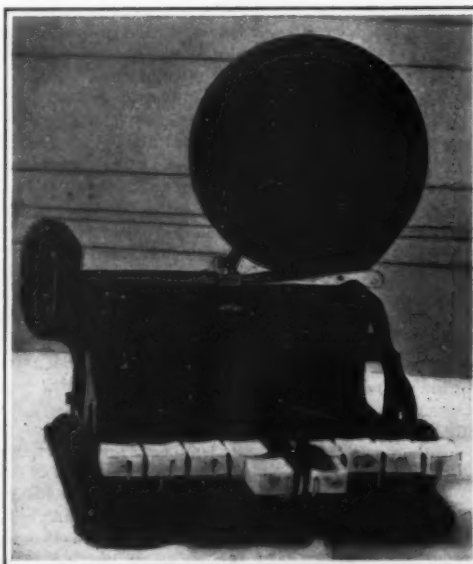
Lieut. Muller's stenoglyph

provided with 12 keys each causing a punch or typebar to strike the paper when hit by the operator, by arranging the keys and combinations of keys according to definite sounds, it is possible to represent each syllable on a record stamped on the paper. By dividing the symbols or signs into groups a system for these sounds may be developed so that they may be readily learned in their relation one to another and to the appropriate sounds. Remarkable as it may seem it is a fact that 12 points may be grouped in 4,095 different ways, and each of these ways conceivably might represent a different syllable sound, but fortunately the division of the stenographic signs into the three groups as mentioned, saves much thought and labor both for the learner and the skilled operator. He merely has to know the meaning of 65 combinations in the grouping. The simple sounds are represented by the single points and the compound sound by a combination of points. For example in the case of the compound sound tr, the two points representing t and r are employed.

This system of notation has the advantage that many

sounds are represented by symbols formed by a few points, avoiding complex strokes of the keys which retard the speed of writing. The frequent use of isolated points hinders reading by touch, as the fingers are not as keen to appreciate their significance or to judge them as easily as where they to perceive the geometric relation between several sets of characters in relief and sufficiently close together to be touched simultaneously The practical field of touch for the fingers does not greatly exceed the dimensions of the rectangle of six points which forms the fundamental sign of the Braille letters.

Prof. Villey when perfecting his invention considered essential elements both in reading and in writing by touch, by providing for the addition of a reference mark in relief which the machine stamps automatically with each sign of a syllable. In this way the space to be examined is restricted for the fingers, and the relative position of each point with regard to the reference mark is obtained in determining its significance. After methodical experiments the inventor determined to replace the single reference mark by two, which permit the blind stenographer to use both hands simultaneously in reading his notes. The points representing the initial consonants are grouped around the first mark while the vowels are placed near the second. A single stroke causes the printing of the two parts of the syllable which are raised on the paper separated from each other and above the two lines.

Naturally the three principles just outlined (The notation of the syllables by one symbol divided into three groups, the employment of two reference marks, and reading with both hands) render it possible to provide many mechanical combinations. In a model recently built by M. Villey, he selected the number of 20 keys and points as the highest possible from the practical standpoint, for the hands of the stenographer need to be moved very little to develop a speed of recording corresponding to the spoken word.

In the case of a blind stenographer and touch reader of unusual skill a speed of 140 words a minute has been achieved with this machine.

The keyboard is composed of two adjacent rows of ten keys, its width being such that the operator readily can compass it with his two hands. One of his fingers with easy motion may strike at will on one or the other of the rows or two keys together. Meanwhile his thumb on account of possessing lesser mobility can press only one key while the forefinger which is the most active can work three. Just like a pianist the blind man strikes a group of keys simultaneously and this is done without his forearm.

The left hand of the operator can handle five keys in each row and these through levers work 10 punches or typebars corresponding to the initial consonants, while the ten keys struck by the right hand act to write the vowels and the final consonants. A band of paper wound around a spool or reel is situated at the left of the machine and moves progressively to the right at each stroke of a key. As it leaves the narrow space which it occupies between the typebars and the corresponding holes required for the impression, the strip carries two lines of characters, the two parts of the sign of the syllable being
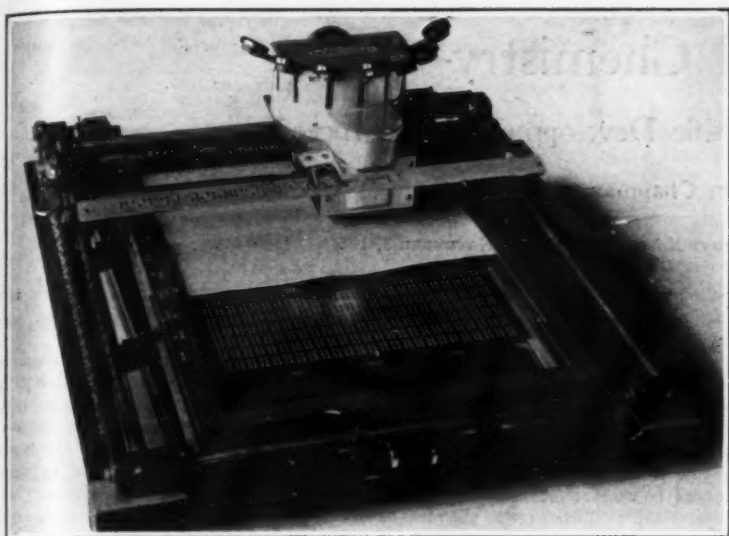
A Swiss machine Invented by Constancon

The Picht, a German production

written one after the other, the second being about four-tenths of an inch lower than the first. In other words the left hand working exclusively on the upper line records one element of the syllable, while the right hand, which operates the lower line, writes the second part of the same syllable. In addition each stroke makes the two reference marks corresponding to each element of the syllable sign, those of the left hand being a horizontal stoke and those of the right hand having a vertical stroke.

For reading the paper strip is passed over a reading table which consists essentially of two reels separated by a surface twelve to sixteen inches wide. Before beginning to transcribe the blind operator first winds one reel of paper on the other in order to measure the task before him. By feeling the paper on the smooth surface between the reels he is able to read the signs, and when he has finished with one part a movement of a pedal causes that to be rolled up and a new section exposed. While the original model of this machine was somewhat heavy, improvements have reduced in weight to less than nine pounds and M. Villey is now working on a stenographic machine with 12 and 16 typebars or punches which he believes will weight considerably less than the nine pound one.

Another recent and important shorthand machine for the use of blind soldiers is that invented by Lieut. Muller, a soldier deprived of the use of his eyes by a German bullet. In this apparatus, the Lieutenant has sought to simplify the task of the blind touch reader. He calls it a *Stenoglyph*. He has followed the example of Villey in using a phonetic stenography based on raised points where each sign represented an entire syllable. The sign basis for the different representation of the syllabic elements consists of 10 points arranged in two vertical columns as indicated in the accompanying figure.

1- 2   to the four upper points, 1, 2, 3, 4, he
3- 4   assigned the 10 simple consonants (that is
5- 6   only those used in shorthand where there is
7- 8   no distinction between T and D, K and S and
9-10   Z, F and V, Ch and J) and in the same way
     the five sounds (Pr.Br), (Pl-Bl), (Cr-Gr),
     Cl-Gl), and (Tr-Dr), much used in French.

To the group of points (5-6-7-8) he assigned the 15 vowel sounds; A-e open or closed. I-O-U, Ou (Oi-Ou-Oin), On-an-in, I E N (Io-Ion-Ia-Ian) (Ie-Ie) (IU-IEU) IOU-(UI-UI). Finally the points 9-10 represent the final consonant (R-L) and (S-X-Z) as the points 3-4 form the cell consonants. M. Muller used 10 consonant signs, 15 vowel signs, and three final consonant signs, or a total of 28 signs, which number is reduced to 25 by repeating R-L-S both as initials and as final.

The Stenoglyph is a mechanical realization of the principles just described, comprising as it does 10 typebars or punches, which are operated by corresponding keys. In the middle of the keyboard and dividing it into two symmetrical parts there is a space bar, so that on a single line there are arranged to the left and right the keys for the points 3-1-2-4-, and 7-5-6-8. These are operated by the second, third, fourth and fifth fingers of each hand. Parallel to the first line of keys is placed to the left of the space bar the key for the point 9 and that for the point 10 to the right. The stenographer works the last two keys with his thumbs, and also the spacer. The type bars or punches moving up and down stamp the characters on a continuous paper strip and thus avoids the loss of time that would be involved in changing the lines.

Lieut. Muller's machine is well adapted to the con-

ditions of practical use. It is small and strong and may be carried about readily, weighing only about 3½ pounds and may be packed in a leather case which carries in addition two rolls of paper nearly 400 feet in length.

The Attar of Rose Industry in Bulgaria

THE most ancient and most attractive Bulgarian industry was the cultivation of the rose, from which was distilled the well-known essence "Attar of Rose." Bulgaria's extensive rose fields are on the southern slopes of the Balkan Mountains, the rose district being 80 miles in length, 30 miles in width, with an average height above sea-level of 1,300 feet.

Several conditions are essential for the cultivation of the rose and the production of the attar. The soil must be easily permeable to water; the bushes must be protected from the cold north winds of the winter; there must be no excess of unseasonable rain, and no early and excessive droughts. These conditions all exist in the "Rose Valley," where the rose thrives as in no other spot on earth. After Bulgaria attained its independence from Turkey in 1878, the Ottoman Government attempted to establish the rose industry in Asia Minor, many acres of gardens being planted around Broussa, where roses grew in abundance; but upon distillation these roses produced practically none of the attar.

In Bulgaria but two varieties of roses are cultivated—the red, "Rosa Damascena," and the white, "Rosa Alba," which are combined in the process of distillation; but the red rose, which resembles the French "Rose du Roi," is richer in perfume and essence than the white. In the Rose Valley, where there are some 20,000 acres of gardens, the atmosphere of the entire district is charged with perfume when the roses are in bloom.

The planting of a rose garden is much like that of a vineyard. The soil is prepared by careful tilling and fertilizing, ditches being dug in rows a foot and a half in depth and width, and a yard and a half aprt. The shoots are planted in the bottoms of these ditches in a mixture of soft earth and manure, and within a year the bushes are about a foot high.

The first crop of consequence comes with the third year. The bushes attain their full growth, about six feet in the fifth year, and continue to yield abundantly for 20 years. There is but one crop a year, the harvest beginning about the third week in May and lasting eighteen to thirty days, the duration depending on weather conditions. In hot summers the harvesting proceeds rapidly, the plants completely flowering in fourteen to twenty days.

The roses, gathered by women and girls, are carried to the near-by distillery, spread out in cool, cemented chambers, and distilled the same day. The gathering continues from daybreak until ten or eleven o'clock, or, if the day is cloudy, for an hour or two longer; roses gathered in a hot sun have a comparatively feeble odor and yield but little essence. In times of rapid harvests the flowers are often so plentiful that they overtax the capacity of the stills and have to be thrown away.

The alembic, or still, is usually of the simplest construction: a convex, tinned copper boiler, narrowed at the top to a neck on which is affixed a spherical head. It is about 3½ feet high, the diameter at the widest part being about 2¾ feet. From the head a straight tube inclines to a warm condenser placed in a tub of running water. The average capacity of the still is 20 gallons, 20 pounds of roses and 15 gallons of water being used. This first distillation, which is completed in about forty-five minutes, yields thirty to thirty-five pounds of rose water, which is redistilled—100 to 120 pounds pro-

ducing some thirty pounds of the second distillate—to get the concentrated extract. The extract is strong in odor and has a turbid appearance from the presence of minute yellow-white globules—the attar—which, being lighter than the liquid, gradually rise to the surface and are carefully skimmed off.

About 20,000 acres are devoted to rose culture in Bulgaria, the annual harvest yielding 35,000,000 to 45,000,000 pounds, or about 8,000,000,000 roses. A one-acre garden under favorable conditions produces 2,000 to 2,500 pounds of roses, from which 10 to 15 ounces of attar of rose may be distilled. Generally, 180 to 200 pounds of roses will produce one ounce of the attar; there are about 200 roses to the pound. The total production of the attar varies with the seasons, but it averages 175,000 ounces.

The largest rose crops on record were those of 1900, 1903, and 1906, which resulted in 180,000 ounces, 210,000 ounces and 225,000 ounces of attar respectively. The 1916 production was small in comparison, not more than 110,000 ounces being distilled.

Nearly all the attar of rose produced in Bulgaria is exported, the largest markets, prior to the war, being Paris, London and New York. The export in 1900 amounted to 180,000 ounces, in 1905 to 210,000 ounces, and in 1910 to 216,000 ounces. The average price, prior to the war, was £2 10s. per ounce.

At one time, during the Turkish *régime*, the rose leaves were sprinkled with geranium oil, which produced a heavy yield of attar upon distillation; but this practice has long since been discontinued, as the attar obtained partook more of the perfume of the geranium than of the rose.

The rose crop of Bulgaria is subject to damage from hailstorms, excessive cold, and early and deceptive spring frost during the budding season, and hot, dry weather in the harvest time. In the last two lies the greatest danger.—*Journal of the Royal Society of Arts.*

Torsional Hysteresis of Mild Steel

THE angular strain produced in bars of steel when subjected to a varying torsional force was measured by the displacement of a beam of light reflected from two mirrors attached at a definite distance apart along the bar. For any given value of the torque, the slope of the stress-strain curve, and thus the modulus of rigidity, was found to depend on the way the stress is changing; at any given stress, including zero stress, it is not a constant quantity but depends on the previous history of the material. Hysteresis loops given by the stress-strain curves on cyclical variation of the load were found to exist at stresses considerably below the accepted elastic limits for mild steel; they increase with the range of loading. By allowing bars which had been overstrained to rest for several days, the width of the hysteresis loop was reduced, and heating to 100° C. had also a marked effect in extending the range in which the hysteresis loop is narrow. This is in accordance with the observation that the elastic limit in compression of cold-drawn steel tubes is raised by tempering at temperatures from 300° to 550° C. Steel in which a condition of overstrain has been produced. e.g., by cutting machinery, may be normalized gradually by a considerable period of rest or rapidly by slight heat treatment. Since fatigue effects depend on the gradual increase of the width of the hysteresis loop with repetition, it would appear that tempering at comparatively low temperatures removes initial stresses and thus considerably increases the resistance of the steel to repetition stress.—Note in *J. Society of Chemical Industry* in a paper by J. J. GUEST and F. C. LEA, *Proc. Roy. Soc.*

Modern Analytical Chemistry—II.*

Some Lines Along Which Its Scientific Development Has Proceeded

By A. Chaston Chapman

CONCLUDED FROM SCIENTIFIC AMERICAN SUPPLEMENT No. 2183, PAGE 288, NOVEMBER 3, 1917

WHILE dealing with the estimation of commonly occurring inorganic acids, mention may be made of the benzidine method for sulphuric acid and the use of "nitron" for the estimation of nitric acid. The former method, which owes its origin to W. Müller, depends on the fact that benzidine sulphate is almost entirely insoluble in cold water in the presence of an excess of benzidine hydrochloride, and since the method is a volumetric one, it possesses the advantage of rapidity.

Notwithstanding that it has been studied and recommended for special purposes by such experienced workers as Raschig and G. v. Knorre, it is obviously very unlikely that any organic compound will ever replace barium as a general reagent for the estimation of sulphuric acid. I have referred to this method rather in the hope that it may stimulate investigation in this direction, since the occurrence of an insoluble sulphate of an organic base, and still more the discovery of an insoluble nitrate, such as is referred to below, render it probable that similar insoluble salts, suitable for analytical purposes and possibly representing some well-defined advantages over existing methods, still remain to be discovered.

In 1905, in the course of an investigation of the endo-iminotriazoles, Busch observed that these bases are characterized by the formation of very sparingly soluble nitrates. By a fortunate chance, it happened that the most readily prepared of these compounds, namely, 1:4-diphenyl-3:5-endo-anilo-4:5-dihydro-1:2:4-triazole, was the one which gave a nitrate possessing the highest degree of insolubility. One molecule of this base unites with one molecule of nitric acid, giving a compound of the formula $C_{20}H_{16}N_4$, HNO_3, and it is capable of giving a precipitate in a solution containing as little as 1 part of nitric acid in 80,000 parts of water.

This base, which can be obtained commercially under the more easily remembered and more euphonious name "nitron," is very easily employed as a reagent, and furnishes us for the first time with a means of making a direct gravimetric estimation of nitric acid. It has been applied with success to the estimation of nitrates in water and in a considerable number of commercial products, such as natural nitrates, nitrocellulose, soils and plants, and is particularly well suited for the estimation of nitrates in liquids containing much organic matter. It has also been found that the method is applicable to the estimation of picric acid, since 1 part in 250,000 parts of water gives a precipitate of the "nitron" picrate. The discovery of unexpectedly useful properties, such as the insolubility of this nitrate—and many other striking examples might easily be quoted—adds a great attraction to the study of pure, synthetic organic chemistry.

I will now pass for a few moments to the application of organic compounds to the quantitative separation and estimation of many of the commoner and some of the rarer metals.

One of the first substances to be used for this purpose, and one which is susceptible of somewhat wide application, is nitroso-β-naphthol, which has been very thoroughly studied by G. v. Knorre and his colleagues. It has been found, for example, that by the use of this reagent nickel may be separated from cobalt; iron from aluminum; copper from cadmium, magnesium, manganese, zinc, mercury and lead; iron from manganese, zinc, nickel and chromium; iron from glucinum; copper, iron and cobalt from antimony and arsenic; and iron from zirconium.

Many of these separations can be effected with ease and with accuracy, the metallic derivatives of the nitroso-β-naphthol being easily dealt with and, being, of course, readily converted by ignition into the corresponding oxides. The copper compound has the formula $(NO.C_{10}H_6.O)_2Cu$.

m-Nitrobenzoic acid has been successfully used for the quantitative separation of thorium from cerium, lanthanum and didymium in the analysis, for example,

of monazite sands, whilst palladium can be readily separated from platinum and other metals of the platinum group by means of acetylene.

De minimis non curat may be true of the law, but it certainly is not true of modern chemistry, which in certain directions is almost coming to be regarded as the chemistry of traces. The importance to the physiological chemist, to the metallurgical chemist, and to the food chemist of being able to detect with certainty small traces of substances is well recognized, and peculiar interest therefore attached to Tschugaev's observation in 1905 that dimethylglyoxime constitutes a delicate test for nickel. He showed, in fact, that it was capable of detecting 1 part of the metal in more than 1,000,000 parts of water, and of affording certain indications, even when cobalt was present to the extent of 5,000 times that of the nickel. The reaction may be represented by the following equation:—

$$2C_4H_8O_2N_2 + NiCl_2 + 2NH_3 = (C_4H_7O_2N_2)_2Ni + 2NH_4Cl.$$
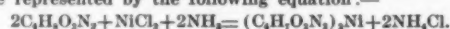
This method has been very thoroughly investigated by many chemists, some of whom have introduced modifications with the object of increasing its sensitiveness. Thus, it has been quite recently stated that, by the adoption of certain modifications, as little as 0.02 mgrm. can be readily detected in 50 c.c. of solution, whilst some years ago Armit and Harden stated that they were able, when working with pure nickel sulphate, to detect as little as 0.001 mgrm. in 30 c.c., whilst 0.003 mgrm. gave a very marked pink color in that volume of liquid.

As a reagent for the colorimetric estimation of traces of nickel, dimethylglyoxime possesses very great and obvious advantages over the ammonium sulphide method. The coloration is more characteristic, traces of iron do not interfere, and the method is, of course, much more sensitive.

As a means of estimating nickel in alloys, particularly in the presence of cobalt, zinc and iron, this method has proved exceedingly useful, being rapid and possessed of a tolerably high degree of accuracy.

Another oxime, namely, a-benzildioxime, originally described by Tschugaev, has been recommended by Atack for the qualitative detection of nickel and for its estimation. It forms an intensely red nickel compound having the formula $C_{28}H_{28}O_4N_4Ni$, containing only 10.9 per cent. of nickel. It is even more sensitive than dimethylglyoxime, and it has been stated that with this reagent, 1 part of nickel in 10 million parts of water can be detected. Like dimethylglyoxime, it has been recently utilized for the detection of traces of nickel in hardened edible fats, in which nickel has been used as a catalyst. When working on 50 grms. of the fat, 1 part of nickel in 5 million parts of the fat can be detected. It is of interest to note, in passing, that the β-isomeride does not yield the nickel reaction.

Another organic compound utilized during recent years for the estimation of nickel is dicyanodiamidine. This reagent, which was originally recommended by Grossmann in 1906, is used in the form of the sulphate, and the nickel compound, which is a well-crystalline, yellow substance, has the composition $Ni(C_2H_5ON_4)_2$, $2H_2O$. By the use of this reagent, nickel may be separated from cobalt, iron, chromium, zinc and other metals, and, given suitable conditions, may be estimated with a high degree of accuracy. It has, in fact, been used very largely, particularly in Continental laboratories, for the analysis of German silver, commercial nickel, nickel steel and other alloys. Although it is not by any means as sensitive as either of the two above-mentioned reagents, it is said to be capable of detecting 0.5 mgrm. of nickel in the presence of as much as 1 grm. of cobalt.

The above methods for the estimation of nickel are of great technical importance, since the precipitates are crystalline and form readily at the ordinary temperature. They can be filtered with ease, they are of constant composition, and the percentages of nickel are not high. The employment of these more or less complicated organic reagents is, as I have indicated, of comparatively recent introduction, and it is not too much to hope that similarly serviceable methods will

be discovered for the separation and for the rapid and accurate estimation of other closely allied elements.

In 1909 Baudisch discovered that the ammonium salt of nitrosophenylhydroxylamine $(C_6H_5.N[NO]ONH_4)$ was capable of being used for the quantitative precipitation of iron and of copper, and for the separation of these metals from a number of others with which they are frequently associated in practice. This substance, to which the simpler name "cupferron" has been applied, has been found to be capable of somewhat wide application, and has proved a valuable addition to our laboratory reagents.

Ferric iron is precipitated completely in cold solutions containing hydrochloric, sulphuric or acetic acids as the compound $(C_6H_5.N[NO].O)_3Fe$, and may readily be separated from aluminum, chromium, and indeed from most other of the common metals, including, by a special process, even copper.

The method has proved useful for the separation and estimation of iron in a number of commercial products, and R. Fresenius, who has submitted it to a critical study, states that the separation of iron and aluminum can be carried out more conveniently and with greater accuracy by the use of this substance than by any other gravimetric method.

I do not propose to enter into any details of the various separations effected by this reagent, but will confine myself to pointing out that by its aid copper may easily be separated from cadmium, zinc and many other metals, and that both titanium and zirconium may be separated from iron and from aluminum. The titanium compound is a bright yellow substance having the formula $(C_6H_5.N[NO].O)_3Ti$.

As an example of the degree of accuracy which may be reached in these separations, it may be pointed out that, when quantities of iron varying from 0.05 grm. to 0.3 grm. were precipitated in the presence of quantities of aluminum and chromium equal to fifty times the weight of iron present, the error rarely exceeded ±0.2 mgrm. I mention this detail merely for the purpose of showing that in the case of these complex organic reagents, the many advantages which are frequently obtained are not necessarily secured at the expense of accuracy.

I think I have dealt at sufficient length with this division of my subject, and I will now turn for a few moments to the consideration of a third main line of advance, namely, that concerned with the utilization of what may be conveniently called biological methods. In the future we may succeed in synthesizing enzymes and even precipitins, but that day is not yet, and for some time to come we must remain dependent on the activity of the living organism for the reagents to which I am now referring.

With the mechanism of enzyme action we are not now concerned. What is of importance from the analytical point of view is its specific character. To such an extent is this the case that the enzymes are actually capable of discriminating between certain of the carbohydrates and their optical isomerides. Thus, d-glucose, d-mannose, d-fructose and d-galactose are fermentable by yeast, whilst their optical isomerides are unfermentable.

In order that a given sugar other than the four above mentioned may be fermented, it is essential that the yeast employed should contain the enzyme necessary for its conversion into one or other of those hexoses. Now yeasts of different species do not all contain the same enzymes, and it happens, therefore, that a certain species of yeast may be capable of fermenting one carbohydrate and incapable of fermenting another.

Of the various enzymes, invertase is one of the most widely distributed among the saccharomycetes, and consequently the great majority of yeasts are capable of fermenting sucrose. On the other hand, lactase occurs in only a comparatively small number of species, and consequently a great many yeasts, including the ordinary brewers' yeast, are incapable of fermenting lactose.

The following table may be of interest as showing the

a glance the behavior of certain of the yeast species towards several of the more commonly occurring sugar:

	Dex-trose.	Fruc-tose.	Man-nose.	Galac-tose.	Malt-ose.	Sucr-ose.	Lac-tose.
Sacch. cerevisiae ..	+	+	+	+	+	+	o
Sacch. cerevisiae, Carlsberg	+	+	+	+	+	+	o
Sacch. Pastorianus	+	+	+	+	+	+	o
Sacch. ellipsoideus.	+	+	+	+	+	+	o
Sacch. Marxianus..	+	+	+	+	o	+	o
Sacch. exiguus ..	+	+	o	+	o	+	o
Sacch. Ludwigii ..	+	+	+	o	o	+	o
Sacch. anomalus ..	+	+	+	o	o	+	o
Sacch. fragilis ..	+	+	+	+	o	+	+
Kefir	+	+	+	o	o	+	+

The sign + indicates that the yeast in question is capable, and the sign o that it is incapable, of bringing about fermentation.

The secretion of any particular enzyme appears to be a very constant attribute of a given species, and it has not been found possible by varying the nature of the food supply or the general environment of a given species to cause it to secrete other enzymes than those normally present. It is this constancy of enzyme production and this selective character that render certain of the yeast species so useful to the analyst, enabling him to arrive at the composition of complex carbohydrate mixtures, the analysis of which would be impossible by any other means.

The method is clearly one which must be applied with caution, and it demands, moreover, some biological training on the part of the operator. The technique, however, is not difficult, and at the present day the majority of analytical chemists, particularly those who are concerned with the analysis of foodstuffs, realize that a certain amount of training in elementary bacteriology is a necessary part of their professional equipment.

It will, of course, be clear that, in addition to yeasts, other organisms which secrete enzymes, such as moulds, may be utilized for analytical purposes, and the preparation of Taka-diastase from Aspergillus oryzae is an illustration in point. Torulæ, again, have recently been pressed into the service, since some of these, unlike the yeasts, do not contain any invertase, and so are capable of fermenting away dextrose and fructose, leaving sucrose unattacked. Biological methods such as I am now referring to are in every day use in the analysis of many sugar products, such as commercial glucoses and invert-sugars, and find extensive employment in the analytical examination of complex carbohydrate mixtures such as many of the prepared foods intended for infants and for invalids.

As one further example of the usefulness of this method, it may be pointed out that, whilst the top yeast as obtained in English breweries converts raffinose into fructose and melibiose, the bottom yeast as obtained in Continental breweries, which contains melibiase as well as invertase, converts it into fructose, galactose and dextrose, that is to say, into completely fermentable products. It is therefore possible by employing these two types of yeast, and by making a simple polarimetric observation, to estimate the amount of raffinose present in a mixture of sugars—a problem which only a few years ago would have been considered impossible of solution.

Another "analytical" method of a more definitely biological character, but one which has already shown itself to be of great practical importance, is that depending on the "precipitin" reaction—a reaction which permits of the identification of so-called homologous proteins and their differentiation from others which they resemble so closely that they are indistinguishable by purely chemical means. The principle underlying the method is that if a solution of any given protein be injected into the blood of an animal, the blood serum of that animal will produce a precipitate with an infusion containing the particular protein injected, but not with any other. Thus, if horse-blood serum be injected into a rabbit, the serum of the rabbit's blood will produce a precipitate when added to an extract of horseflesh, but not with an extract of any other kind of flesh. It thus becomes possible by means of this method to identify horseflesh in mixed foodstuffs, such as sausages. It is also possible to detect small quantities of castor seeds in feeding cakes, to distinguish between hen-egg albumin and the albumin of the eggs of other birds, between the milk of one animal and that of another, between genuine and artificial honey, and even, so it is stated, between the seeds of two-rowed and of six-rowed barley. The importance of the reaction for the identification of human blood in medico-legal investigations is well recognized.

I have now touched on a few of the main lines along which analytical chemistry has advanced during recent years, and have endeavored to show that, so far from being the exhausted and lethargic handmaiden, it is, in fact, as alive, as progressive, and as originative of research as any other branch of our science. That this is not always fully realized, and that there has been—and is even now in some quarters—a tendency to regard analytical chemistry merely as a useful art and its practitioners as highly skilled laborers, is unhappily the case. That there are here and there a few analysts to whom that description might be correctly applied is undoubtedly true, but the same is, of course, equally true of the medical and other professions.

The analytical chemist of to-day is, in fact, being continually faced with new problems that frequently demand for their solution the possession in a high degree of those special qualities of intellect and character which go to make the successful investigator in the domain of pure chemical science. For many chemical consultants life is a continuous series of technical problems, and I am not indulging in any exaggerated language when I say that the really successful consulting and analytical chemist must not only have a good general scientific training, an extensive knowledge of general chemistry, and a genuine love of his work, but he must be mentally alert and adaptable and possess the aptitude for research in a high degree.

With regard to the teaching of analytical chemistry, there is much that I should like to say if time permitted, and in particular I should like to plead again for the establishment in our universities and university colleges of chairs of analytical chemistry. I have already dealt with this subject at some length in an address to another society, and perhaps I may be allowed, in concluding, to quote the following remarks from that address:—

"Having very briefly touched on the nature and extent of the scientific equipment needed for the successful practice of analytical chemistry, we may reasonably inquire whether the training which our young professional chemists obtain is such as is calculated to insure the best results. Whilst there may possibly be some difference of opinion as to the precise position which a study of chemical analysis should take in the training of the chemical teacher, there can surely be none as to its supreme importance in the training of the professional chemist. In the great majority of cases it is the actual instrument by which, directly or indirectly, he is to earn his livelihood, and in every case it must tend to produce (if properly taught as a living subject and not as a mass of tedious prescriptions and formulas) a deeper insight into the nature of chemical reactions, an appreciation of the influence of mass and other disturbing factors, and a recognition of the importance of attention to minute detail. In addition to this, it affords endless opportunity for the acquirement of dexterity in constructing and manipulating scientific appliances, and in all these ways renders invaluable service in the making of the successful technical chemist. Now, if all this be true—and I do not see how it can be denied—analytical chemistry ought clearly to take an outstanding position in our universities and university colleges, as it is from them that, more often than not, the young chemist proceeds directly to the practice of his profession. Unfortunately, the position which it takes in those institutions is not, as a rule, a high one, nor one at all commensurate with its importance. I believe I am correct in saying that in no university in this country does a chair of analytical chemistry exist, and that a subject which is admittedly of such great, great importance is entrusted to teachers who, however well qualified and capable they may be, have, as a rule, to teach it, if I may use the expression, incidentally. . . .

"So large a subject, and one which is in constant process of development, might well, it seems to me, be entrusted to a specially appointed professor, who would have the opportunity of keeping himself fully abreast of the developments of his subject, and who would have the time to deal with it in a manner practically impossible under the existing conditions. Such chairs of analytical chemistry exist in very many of the more important American and Continental universities, and it can scarcely be contended that what has been found desirable in so many other parts of the civilized world is unnecessary in Great Britain. Chairs of analytical chemistry, for example, exist in Yale, Virginia, Johns Hopkins, Cornell and Columbia universities, to name only those of which I know and I believe I am correct in saying that in Columbia University there are no fewer than three such professors. In many of the university prospectuses great emphasis is laid on the importance of analytical chemistry, and from one of the Yale calendars I cannot refrain from quoting the following words: 'There is probably no branch of chemical study as important as qualitative analysis in its use in developing the reasoning faculties and enabling the student to generalize and to classify chemical phenomena.' In Heidelberg, Munich, Leipzig, Würzburg, and other German universities, in the Imperial technical high schools at Stuttgart, Vienna and elsewhere, such chairs exist, as well as at Upsala, in most of the Swiss and Belgian universities, and in some of the Italian. In regard to France and one or two other countries I have no definite information, but I think I have said enough to establish my point—that in many of the world's leading universities the teaching of analytical chemistry is entrusted to a specially appointed professor, who takes equal academic rank with his other chemical colleagues. Even when this is not the case, assistant professors or special assistants are frequently appointed to deal solely with this branch of chemistry. It clearly cannot be objected that it has not been our custom in this country to appoint professors to deal with special branches of chemistry, since in some of our colleges chairs exist devoted to physical chemistry, biochemistry, tinctorial chemistry, fuel chemistry, brewing chemistry, agricultural chemistry, technical chemistry and metallurgy.

"I am not foolish enough to imagine that the establishment of chairs of analytical chemistry in all or any of our universities and colleges would bring forth a new heaven or a new earth, but at least it is certain that this highly important branch of chemistry would be taught under better conditions than those which in many cases exist at present. The teachers, being in a position to devote themselves entirely to their special branch of instruction, would be able to give more time and attention to the student, and surely in no branch of chemistry is close and constant supervision of practical work so necessary. They would also have the time to make themselves thoroughly conversant with their subject in both its theoretical and practical aspects, as well as to keep in touch with modern developments, and their laboratories might even become in process of time centers of original work in a department of our science in which research has been for so long neglected."

The Use of Titanium in the Manufacture of Steel Castings

NOTWITHSTANDING all that has been said regarding the harmful effects of phosphorous and sulphur in steel castings, occluded gases and oxides are the real causes of many of the troubles of the steel foundryman. In the elimination of these difficulties, ordinary dioxidizers such as ferro-manganese and ferro-silicon have their place, but if the best results are to be achieved a more potent reagent is necessary, and for this purpose ferro-titanium has proved unusually satisfactory. Titanium undoubtedly is one of the most powerful dioxidizers and denitrogenizers known. The chief value and merit of titanium lies in its positive action in the removal of occluded oxides, nitrogen and entrapped slags. The present-day method of using ferro-titanium is to augment the incompleted cycle of reactions with ferro-titanium after the other deoxidizers have been added. Ferro-titanium additions are of value to the foundryman in making low or high-carbon or alloy steels. The results are not due to any direct or alloying effect of the titanium, but rather to its value as a deoxidizer and cleanser in removing harmful occluded gases and slags. Titanium, however, must not be looked upon as a cure-all to rectify the evils of poor stock selection and bad furnace practice. Its function is to make good steel better. In these days of high priced ferro-manganese, ferro-titanium can be used to advantage to decrease the consumption of the manganese alloy.—W. A. JENSSEN in Proceedings of the American Foundrymen's Association.

Carburization of Iron by Cyanides and Cyanates

WHEN iron is case-hardened by heating at 800°—900° C. in presence of cyanides or ferrocyanides, cyanates are always present. The effect of the cyanates was studied in the carburizing of iron wires ($C = 0.03—0.08\%$, $Mn = 0.41\%$) in which mixtures of potassium cyanide and cyanate in different proportions were used. It appeared that cyanates were necessary to rapid carburization, and the best results were obtained when $25—40\%$ of cyanate was present in the mixture used. This is perhaps the reason for the inclusion of oxidizing agents (potassium nitrate or bichromate) in case-hardening mixtures.—Note in Jour. Soc. Chem. Ind. on an article by PORTEVIN in Comptes Rendus.

Coal Gas for Motor Vehicles*

A War Substitute Being Tried in England

In our issue for the 31st ult., an article was given which dealt with the substitution of coal gas for petrol, and traced the progress made with the newer fuel. Since the publication of this article there has come to hand a most illuminating report, dealing with experiments conducted with coal gas by the Executive Committee of the British Commercial Gas Association. It was known in the early part of the year that this association had interested itself in the matter, and the report is one which has been awaited with considerable interest by all who have been watching this latest development in motor traction. The committee states, that the only substantial difficulty in the way of substituting coal gas for petrol is the bulk of the gas; accordingly, chief attention has been given to various storage systems, and to such important considerations as the effect of compression on the quality of the gas. As regards the more common method of storing the gas under normal pressure in a large flexible container, it is pointed out that the practical disadvantages of this system are the extremely fragile nature of the holder and its bulky dimensions, which seem to unfit it for hard work in towns. Nevertheless, the simplicity and low cost of the system warrant careful consideration of it as a war measure, because, although the volume of gas that can be carried at atmospheric pressure is limited owing to its bulk, this disadvantage is to some extent compensated for by the ease with which the gas-holder can be replenished. Indeed, in view of the present difficulty of obtaining pressure receivers, it is hardly possible to use gas in any other way. It is pointed out that owing to the very low pressure—only about two-tenths of an inch water gage—exerted by the gas contained in a flexible container, a meter delivering into it discharges practically as though it were open to the atmosphere, and, accordingly, races unless some form of throttle is interposed. A short length of small bore piping or a diaphragm with a suitable aperture is recommended so as to retain the pressure drop in the meter within reasonable limits.

Consideration is given to the method of storing the gas under pressure in steel cylinders, and, for practical reasons, a pressure varying from 20 to 25 atmospheres is recommended. It is particularly instructive to note that the effect of compression on the calorific power of coal gas, if the compression is carried to 120 atmospheres, is a reduction amounting to 10 per cent. In experiments made to test this point, a cylinder of gas at a pressure of 120 atmospheres was discharged through a reducing valve into a calorimeter, and frequent observations of the heat developed were made. It was found that the calorific value remained almost constant during the time the gas was discharging and the pressure falling. There was, however, a rise in the number of B.t.u. developed during the last few minutes, when the pressure was falling from about three atmospheres to atmospheric datum, presumably due to the partial re-evaporation of some of the hydrocarbons which had been precipitated. The main point, however, is that almost the whole gas can be discharged at a practically constant calorific value, and this value is 10 per cent lower than before compression.

There was no opportunity of determining, under existing conditions, the effect on calorific value resulting from compression to 20 atmospheres; but from observations made some seven years ago, it was found that the deterioration due to compression to 300 lb. per square inch was from 3 to 4 per cent, so that if due allowance is made for the difference in constitution of the gas at the present-day the effect of compression would be almost negligible. Compression, moreover, has its advantages, for up to 20 atmospheres the gas would deposit 95 per cent of its normal water content, and, as in practice it would have very little opportunity of taking up further moisture on its release from the storage cylinders, it would be employed practically dry. In this way the avoidance of dilution with water vapor would counterbalance the loss of calorific value due to the deposition of hydrocarbons.

*The Engineer.

Car equipped with a gas-carrying trailer that contains 280 cubic feet illuminating gas, equivalent to about 1 1-4 gallons of gasoline

HYDROCARBONS PRECIPITATED

As regards the hydrocarbons thrown down by compression, there is no doubt that napthalene will be precipitated; but observation shows that there is invariably a sufficiency of liquid constituents to prevent the naphthalene from assuming the solid state. These liquid constituents, however, have a tendency to polymerize; accordingly, it would seem desirable that storage containers should be fitted with drain cocks, while it would be as well if provision were made for the periodical use of a small hand-operated spraying device to facilitate the expulsion of viscid deposits. A further point in
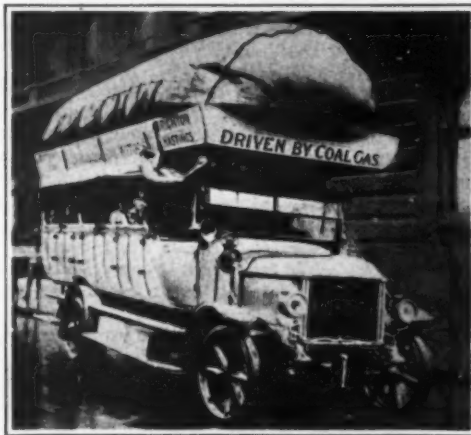
The gas bag on top of this car contains enough fuel to run it ten or twelve miles

favor of moderate compression is the fact that there would certainly be a greater deposit of hydrocarbons at extreme pressures, such as 120 atmospheres, and at the same time there would be greater difficulty in cleaning out the containers. Probably it would be necessary to expel the deposited matter by means of heating, which would entail the dismantling of the vessel—an expensive matter. In time, too, the periodical heating would adversely affect the strength of the cylinders. Another point is that with compression to 120 atmospheres the containers would be smaller while the deposits would be greater than at 25 atmospheres, so that the volumetric capacity of the cylinders would suffer serious diminution unless they were frequently cleaned.
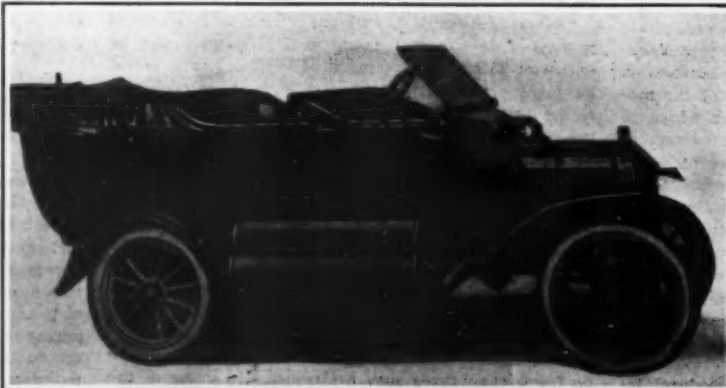
The cylinders on the running-board contain 500 cubic feet of illuminating gas. The cylinders weigh about 675 pounds

The British Commerical Gas Association equipped a special car for gas-consuming purposes, and carried out experiments in this way. The car was run round a district having about the average kinds of roads and variations of level, and the observations made indicate a radius of action of twenty-five miles per thousand cubic feet of gas. The average speed was nine miles per hour, including the stopping and slowing down, which was several times necessary at crossings, etc., but which is, of course, consistent with every-day conditions. It was not found possible to make comparative brake tests as between gas and petrol; but tests made by Messrs. White and Poppe, of Coventry, show that the brake power developed by a petrol motor when driven by gas is about 85 per cent of the power developed by petrol, and that this proportion is fairly constant over a wide range of speeds; also for equal brake power on test bench, one gallon of petrol appears to be equivalent to 250 cubic feet of gas. These tests were made with gas compressed to only a few inches; but so far as the data of relative power are concerned, there is no reason for doubting that they apply equally well to gas that has been compressed, making due allowance for loss of calorific value due to compression, which, however—as has already been pointed out—may be regarded as negligible for pressures not exceeding 25 atmospheres. The committee's own observations, derived from general running of a vehicle on petrol and gas, point to a ratio less favorable to gas, namely, that one gallon of petrol is equivalent to 300 cubic feet of gas. Much, however, depends upon the quality of the gas and the kind of petrol used. Several particulars are given with regard to the weight of the cylinders, and it is shown that compression to 120 atmospheres would mean a tangible economy in this direction. There is always the fact, however, that the high-pressure cylinders work at a lower factor of safety, which in turn necessitates a degree of supervision which seems scarcely practicable with reservoirs used for the storage of gas for motor traction. Moreover, the extreme high-pressure cylinders are more expensive per 1,000 cubic feet of free gas than are cylinders for the more moderate pressure of 25 atmospheres; but this item, on the other hand, would soon repay its cost by the higher carrying capacity of the vehicle, due to the smaller deadweight.

CHARGING DEPOTS

So far as the equipment of compressing and storage depôts is concerned, it is recommended that the station units should, for economical as well as mechanical reasons, be of the multiple type rather than in the form of a single reservoir, and should be worked at a pressure rather higher than that required on the car, so as to compensate for the drop of pressure that would take place when the gas was transferred. If when the pressures in the car cylinders and the station storage cylinders had adjusted themselves, this pressure was below the working pressure for the car, direct communication with the compressor would allow of the necessary addition being made. A suitable arrangement of valves would permit of this being quickly done. If the compressor were not supplemented by a certain amount of storage capacity in the form of auxiliary reservoirs, it would have to be of such size as to permit a car to be replenished in, say, five minutes, which would mean a compressor of 12,000 to 18,000 cubic feet per hour capacity, and, unless the demand for gas were high this would add unduly to the standing charges and, therefore, to the cost of compression.

No trouble has been experienced in the reduction of temperature consequent upon the expansion of the gas after release from the storage cylinder. The gas was observed to chill immediately after release, but nothing else; the conductivity of the metal surroundings being sufficient to make up for the absorption of heat due to the expansion of the gas.

A point in favor of coal gas which must not be overlooked is the extremely clean conditions which prevail with its use. Petrol certainly possesses the immense advantage of containing a large amount of energy in a small space; but coal

gas, on the other hand, being for all practical purposes a "perfect gas" and not a vapor, conduces towards clean pistons and cylinders, absence of troubles due to injector stoppage, and the complete elimination of starting difficulties in cold weather. As the gas supplies in different parts of the country are not standardized either as regards quality or price, the gas obtained in some localities will give a better mileage than that obtained in others; the gas equivalent, however, is unlikely ever to be higher than 300 cubic feet per gallon of petrol, but it may be as low as, or even lower than, 250 cubic feet.

A New Method of Artificially Loading Generators for Test*

By Robert Treat

Power and Mining Engineering Department, General Electric Co.

In making tests on hydro-electric plants, it is quite frequently found necessary to provide artificial loads for the generators. In such cases it has been the general practice to use a liquid rheostat formed by placing the electrodes in either the forebay or the tailrace, according to convenience, or sometimes in a special tank with salt solution. Such an apparatus, besides having numerous troubles of its own, produces only a unity power-factor load; whereas the majority of generators are designed for operation at about 0.8 power-factor. A scheme free from the objections to the liquid rheostat method was first made public in a paper on the Huronian Company's Power Development by Robert A. Ross and Henry Holgate, read before a joint meeting of the Mechanical and Electrical Sections of the Canadian Society of Civil Engineers, April 25, 1907. Since then the method has been used a number of times in various tests by R. A. Ross & Company, Consulting and Supervising Engineers of Montreal. Through the courtesy of Mr. J. Norman Smith, Chief Engineer of that Company, the writer has been given the most important details from its experience; and these are now published for the benefit of any who may desire to use this method.

This same scheme was independently originated and successfully used by Mr. O. H. Ensign, Chief Engineer of the United States Reclamation Service, in testing the generators at the Cross Cut Hydro-electric Station. Salt River Project, accounts of which have occurred in the technical press.[1]

With these exceptions, this method of loading generators does not seem to be as generally known as its merits justify.

The scheme is exceedingly simple, and consists merely in connecting another generator (when one is available) to the machine under test, with one phase reversed, so that the load generator runs in the opposite direction of rotation as a synchronous motor. When both machines are up to speed and are excited to full voltage, the gates of the wheel which is motoring are gradually opened until the required load is obtained, the wheel in this case acting as a water brake. The generator and motor fields may now be varied to produce any power-factor and voltage desired.
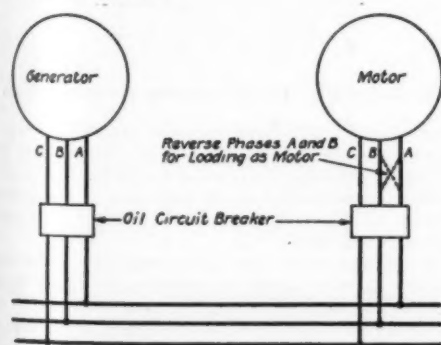

Fig. 1.

New Method of Artificially Loading Generators

The following instructions prepared by R. A. Ross & Company for the guidance of its men are of interest:

INSTRUCTIONS FOR RUNNING WATERWHEEL GENERATOR-MOTOR TEST

1. Transpose any two legs of the motor leads (this will reverse the direction of rotation of the motor; see Fig. 1: say place B in A and A in B on the motor leads).
2. Close the main generator switches connecting the generator and the motor electrically together.
3. Excite both the generator and the motor.
4. Admit water to the generator wheel only, until both machines are turning over.
5. Note that the motor is operating in the reverse direction to that which it would operate as a generator.

*The General Electric Review.
[1]Engineering News, April 20, June 22, 1916.

6. Raise the voltage and the speed of the generator to normal by operating its field rheostat and by admitting water to the generator wheel.
7. Admit water slowly to the motor waterwheel to act as a brake, as required, to secure any desired load on the generator up to its wheel capacity.
8. Vary the field excitation on the generator and the motor to secure any desired power-factor.
9. The generator instruments will indicate the output of the generator; the instruments on the motor need not be taken into consideration.
10. If the exciters are directly connected to each generator and one exciter is not sufficient to excite the two machines, it will be necessary to reverse the exciter connection on the motor exciter to suit the reversal of direction of rotation.
11. The governor mechanism should be disconnected from the motor, as it might be damaged by reversal of rotation, but an operator should be in attendance, to shut off the water to this wheel, in case of the circuit opening to the motor, when the water passing into the motor waterwheel would stop same, and reverse direction of rotation, causing it to speed up rapidly and possibly run away.
12. By actual operating conditions it has been found that quite a small gate opening on the motor water wheel isall that is necessary to produce full load on the generator under test.

A few of the troubles experienced by others are noteworthy. One most important point is to have the draught tube of the motoring unit filled with water before attempting to start; otherwise the hunting and surges set up by the wheel revolving against a load which is intermittent rather than steady may trip the oil circuit-breakers, or cause the machine to break from synchronism. On starting, the motoring unit cannot be started from its own wheel, as it would then run in the wrong direction. Usually two duplicate machines can be started together from rest, as described in the foregoing instructions; viz., by exciting both fields, connecting the armatures together, and admitting water to the generator wheel until it starts. The low-frequency currents produced in the generator armature will then drag along the field of the motoring unit and the two machines will run in synchronism from the start. Trouble may occasionally be encountered due to high static friction in the bearing of one or both machines. This would necessitate opening the generator wheelgate so wide, in order to "break it from rest," that the resultant large amount of water would cause the generator to accelerate too rapidly and it would break from synchronism with the motor. This may be overcome, in some cases, by starting the machine as a plain induction motor; *i. e.*, by not exciting the motor field until it is partly up to speed. If this is not successful, the gates of both units may be opened just enough to start them turning over, *without* switching them together. As soon as the units start revolving, the gates should be closed and field applied to whichever unit is necessary to make them come to rest *at the same instant*. Just before they stop they should be switched together, fields applied to both machines, and the generator gate opened until they start together. This procedure will eliminate the high static bearing friction and no difficulty should then be experienced in getting started. It is doubtful if much trouble will be encountered with horizontal units; but vertical machines, expecially those equipped with Kingsbury or plate-type thrust bearings, are likely to be obstinate. It should be particularly noted that Kingsbury bearings are usually designed for *one direction of rotation only*, and some care must be taken when applying the test herein described to machines equipped with them. However, instances are known, particularly the tests at Cross Cut previously mentioned, where Kingsbury bearings have been run backward without any apparent distress.

The question may be raised as to what effect this method of testing will have on the water wheels; whether impelling them directly against the flow of water will not result in strains and distortions that may be injurious. The writer has referred this subject to a number of the most prominent waterwheel builders in the United States, and very few have cared to make any very definite statements on this point. The consensus of opinion, however, seems to be that there is little question of harmful stresses in high-head wheels, but there may be some doubt as to low-head units. The writer would recommend conferring with the waterwheel builders in each individual case where this method of test is being considered. It is believed that when this method shall have become better known and more generally used, wheel builders will be less conservative about approving it.

For much of the information of interest and value appearing in this article the writer desires to express his appreciation to Mr. W. A. Doble, Chief Engineer of the Pelton Waterwheel Co.; to Mr. J. Norman Smith; to Mr. O. H. Ensign; and to various waterwheel builders through their engineering organizations.

Rood Screens in the East Riding of Yorkshire

In a special number of the *Yorkshire Archaeological Society's Journal*, Mr. Aymer Vallance gives a history

of these roods and screens, with topographical notes, and numerous photographs of such screens as have been preserved, taken by Mr. F. H. Crossley. It makes a most valuable chapter in Yorkshire ecclesiastical history. Unfortunately it is not complete. Some of the eighteenth century parochial records are bald, but they reveal a sturdy independence on the part of clergy and laity in various places, and a refusal to obey the authority which ordered the destruction of screens. Dr. Heneage Dering, who was Archdeacon of the East Riding throughout nearly the first half of the eighteenth century, was officially responsible for the mutilation of many. Mr. Vallance says nothing about this famous Yorkshire dignitary except in quoting again and again from the records—"The Archdeacon ordered the rood-screen to be abolished," or "to be cut down." In a large number of churches his orders were obeyed, whether with or without protest is not stated, though it is clear that in other parishes the destruction was regarded as an outrage upon religious sentiment, or at least a Philistine-interference. At Hollym, for example, instead of destroying their screen, the vicar and churchwardens transferred it to the north side of the church; at Kirkburn, where the Archdeacon ordered that the screen would be "cut down," it was allowed to remain, and was still standing "gates included," in 1817. As the Archdeacon gave the order in 1725, and filled the office of Visitor for a quarter of a century afterwards, it is to be assumed that he knew that his orders were defied. At Lockington the Rev. John Whitty "staunchly refused to let our churchwardens pull down the partition betwixt the church and chancel," and at Skirlaugh little attention seems to have been paid to Dr. Dering's wishes.

In many places, however, the offending screens were "cut down" or taken away. Some disappeared altogether. The most beautiful screenwork was chopped up, and probably used as firewood. In a few cases the screens were "saved," but allowed to decay in lumber rooms. There was a remarkable instance of such neglect of quite recent date at St. Mary's, Beverley. When the screen was removed is not known, but probably it was in 1875 or 1876, in the process of refitting the chancel. Mr. Vallance says the incumbent, the Rev. E. Carr Glyn, afterwards Bishop of Peterborough, effectually opposed its replacement, and it then lay "neglected and decaying for years in the damp crypt under the chapel east of the north transept." It was largely due to Dr. Stephenson's initiative that it was rescued and replaced, though apparently not exactly in its original position. An even more surprising story is told of Welwick, two miles from Patrington. About 1870 the east window of the church was filled with new painted glass, "and the parish was so enamoured of the result that, in order to obtain a full and uninterrupted view of the window, the rood-screen was cut down to the middle rail level." The dismembered portions were put in the coal-place, and were used to feed the church stove. "This discreditable state of things" continued for years, but at last Mr. John Bilson, F.S.A., collected the loose mouldings and carvings, refitted them, and having repaired the whole screen, re-erected it in 1906.

Of Beverley Minster it is recorded that Archbishop Aldred, during his pontificate in the early part of the twelfth century, caused to be built over the quire entrance "a pulpitum (rood-loft) splendid beyond compare, of bronze and gold and silver." The rood "reared up aloft in the head of the opening, artificered likewise in bronze and gold and silver of Teuton craftsmanship." The images were removed by Royal injunction in the reign of Edward VI. (1548), when the collegiate establishment was dissolved. What became of the gorgeous pulpitum is not known. Mr. Vallance thinks the only surviving relic is the overhanging canopy of carved oak above the stalls on either side of the quire. The date of this beautiful work is about 1520-24. The existing screen was set up in 1731, displacing one of so bizarre and hybrid a nature as to defy classification. The real interest attaching to it, says Mr. Vallance, is that it "perpetuated still, in a most degenerating age, the ancient English tradition of a pulpitum embellished with figure sculpture." Two figures representing King Athelstan, the founder of the Minster, and St. John of Beverley, Bishop, were cast in lead by W. Collins, at his foundry in Driffield in 1781. These figures are preserved on pedestals in the nave, near the south door. Of the famous screen in Flamborough Church, one of the most beautiful in England, Mr. Vallance remarks that probably rood-screen and rood-loft were in situ until about 1866. It has been restored, and is preserved with great care. The height of the parapet is 5 ft. 3 in. over all; and the total height from the summit of the parapet to the foot of the screen is 14 ft. 10½ in.—*The Architect*.

Radio-Active Halos*

Minute Rock Markings of Importance to Our Views on the Physical History of the Earth

By Prof. J. Joly, F.R.S.

THIS discourse is concerned with certain very minute objects of the rocks—so minute as to be visible only with the aid of the microscope—known to petrologists by the cumbersome name of "pleochroic halos." Although we shall be occupied mainly in considering quite recent additions to our knowledge of halos, yet, in view of the fact that many of this audience will probably hear of them now for the first time, it is necessary to begin with some elementary remarks.

The halos of the rocks have been known since the application of the microscope to rock study; but until recently their origin and nature were quite unknown. Nor could it have been otherwise, for they find their explanation in the facts of radio-active science only—a science the origin of which dates back but little before the beginning of the present century. The student of the rocks in past times seems to have regarded these objects with but little more than passing interest. Had he paid more attention to them a case replete with extraordinary mystery could have been made out, and one which at the time must have remained absolutely inexplicable. The lack of attention to the detail displayed by halos, and the failure of the earlier observers to notice the mathematical regularity of their dimensions, well illustrate how advance in one domain of science may influence our recognition of facts in another.

The most familiar type of halo consists simply of a darkened border surrounding some minute mineral particle within the rock. The formation of the colored border indicates some alteration in the medium in which it is formed, and this alteration is evidently conditioned by the presence of the central mineral. If the latter is very small and about equally developed in all directions, the halo takes on the form of a sphere having at its center the mineral which has originated it. In a section of the medium containing the halo this sphere appears as a colored disk; but as we find the same appearance, no matter in what direction we section the halo, its spherical form is beyond doubt.

Certain facts respecting the formation of halos have for long been available. Only quite a few substances can originate a halo. Of these the minerals zircon and orthite are the commonest, and the first much more so than the second. Again, only in certain media surrounding such minerals can a halo be developed. Of such media the several varieties of brown mica are the most abundant and the most valuable. It would appear that all media sensitive to the formation of halos contain iron as a constituent.

While these facts have long been available, the next I have to mention is a recently discovered one. All those minerals which give rise to halos are found, when examined in large crystals, to contain radioactive substances.

Now, such substances, we well know, are continually radiating. They give out various sorts of rays. This leads us to suspect that the halo may, in fact, be generated in some way by these radiations. There are three sorts of radiation—the α, β, and γ rays. The last two cannot possibly be responsible. They are far too penetrating to account for these microscopic effects. The α rays can alone be concerned.

Before pursuing further our inquiry in this direction, let us examine the nature of the halo itself. It is not merely a stain or lodgment of coloring matter in the medium. If we apply optical examination with polarised light to a halo in brown mica we find that the peculiar optical properties of the mica, which are, of course, referable to the orderly arrangement prevailing among its molecules, exist within the halo just as elsewhere. In fact, we might say they are accentuated. The remarkable absorption of the ray polarized in the plane of cleavage of the mica is more complete in the halo. We occasionally see a halo which extends across the edges of two distinct flakes of mica. If the light is polarized and the plane of polarisation is in the plane of cleavage of one of the flakes, and is inclined to the cleavage of the other flake, that part of the halo which is contained in the first crystal of mica is intensely black. In the other crystal of mica the halo is much lighter in color. Plainly the effect upon the mica, however exerted, has been such as to increase the absorption of a ray vibrating in the plane of cleavage. The crystallographic structure has not been disturbed. If iron is not a constituent of the medium no visible effect is produced. Of the last statement we sometimes find very beau-

*A discourse delivered at the Royal Institution and reported in *Nature*.

tiful evidence in the case of halos which originate from a nucleus located outside the sensitive medium, but within a certain distance of it. Fig. 1 will explain. The originating crystal is in quartz, a substance which never contains halos. There is no iron in its constitution. But the halo-forming influence extends to a neighboring crystal of mica. This influence, which develops an outlying part of the halo-sphere in the mica, must have traversed the quartz. It has left no record therein. If the halo was something of the nature of a stain diffused
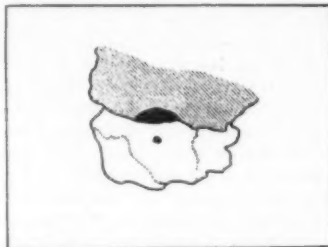
Fig. 1.—Nucleus of halo located outside a sensitive medium

outwards from the central substance—as some of the earlier observers maintained—the absence of the coloring material from the quartz is not easily explained. But if the halo is—as we have hinted—due to radiations proceeding from the zircon—radiations which only affect certain unstable atoms—the appearance at once finds simple explanation. The quartz is not sensitive to the rays; the mica is.

But the primary evidence for the radio-active origin of the halo is to be found in its dimensions. The fully developed halo has been found in two sizes. One of these shows a radial dimension of 0.0333 mm.; the other scales, radially, 0.0408 mm. There are two primary radio-active elements, as everyone knows—uranium and thorium. If the central or originating substance contains uranium it will of necessity contain all the eight α-ray-emitting substances which the uranium-radium series embraces. Similarly, if the central substances contains thorium, there are seven α-ray-producing substances which must be present. Now each of these various radiating substances emits α rays which possess a certain specific velocity of emission, and, consequently, a specific power of penetration. The most penetrating ray of the uranium series is that of radium-C. In air this ray will travel 6-94 cm. before it comes to rest. The most penetrating ray of the thorium series is that of thorium-C. This will penetrate 8.60 cm. before coming to rest. A very few rays travel further, but this does not affect the matter. Now Bragg has shown how we may calculate the range in any medium if we know its chemical composition and its density. We can, accordingly, calculate what the range of these extreme rays should be in mica. When we do so we get exactly the dimensions of the two sorts of halo. We shall presently see that even this evidence is but a part of the case for the radio-active origin of the halo.

Uranium halos—that is to say, those in which uranium is the parent radio-active mineral contained in the central zircon—are common. Such are not generally
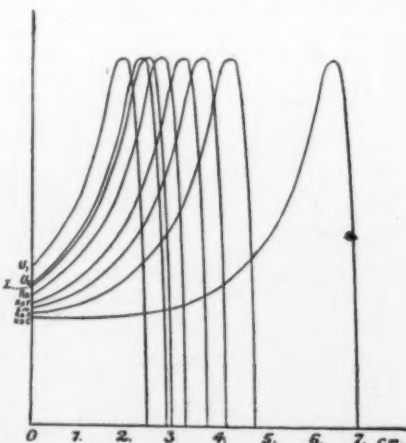
Fig. 2.—The eight ionisation curves forming the uranium halo

capable of accurate measurement. But in clear, flawless mica, viewed on the plane of cleavage, halos of extraordinary delicacy and sharpness of outline are sometimes met with. Again, the halo is often completely blackened up. Such halos may be described as "over-exposed." As in the case of different exposures in photography, we find every gradation in the amount of detail according to the amount of action which has taken place.

We must remember that the causes which have given rise to the halo are highly complex. We may represent the several rays concerned as generating a number of concentric spheres of ionization, the radii of which are in correct relative proportion to the penetration of the several rays.

But this fails to represent the full complexity of the conditions. Each ray behaves in a very remarkable way. To enter into this matter here is impossible. We must be content to recall that the effects of the α ray in ionizing the medium in which it travels varies along its path. It appears certain that its influence on the mica, or in whatever mineral it generates the halo, depends upon its power of ionizing the atoms with which it comes into effective contact. Now the number of ions created along its path remains at first fairly constant, but rapidly increases towards the close of its career, just before its effects become naught. Bragg's well-known curve shows the manner in which the ionizing effects in air of a single α particle vary along its course. This curve applies to all rays, however short the range; we must simply curtail the length of the earlier part of the curve when the range is short.

Now, if we assume that the distribution of effects of the ray along its course in the mica are much the same as they are in a gas, we see that along any radius of the halo-sphere we must admit the effects of eight rays, each ray penetrating a distance depending on its initial velocity and acting upon the mica in the manner
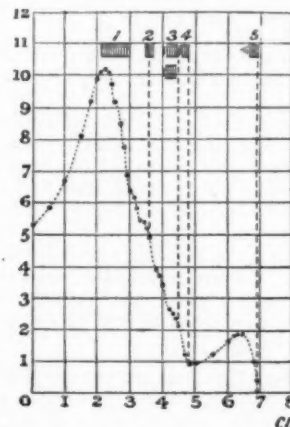
Fig. 3.—Integral curve of ionisation for uranium halo

represented by the Bragg curve of ionization. Fig. 2 shows you that by adding the ordinates at any point we can find the integral or total ionization due to all eight rays so far as they produce an effect at that point. The curve of total ionization follows (Fig. 3).

But even this curve does not represent the entire conditions. It may be said to represent the effects along a radius of the sphere which has been traversed by all the eight rays. But the radii of the sphere are, of course, diverging from the center. The net effects which generate the halo must therefore grow weaker outwards. When we make the requisite allowance for this, nearly all the detail of the last curve disappears, and we are given as the theoretical structure of the halo a steadily diminishing density outwards until we reach such a distance from the center that RaC_1 or ThC_1—as the case may be—begins to exert its separate effects. These effects then appear as a penumbra-like border surrounding the inner darkening. I now show you, for the case of the uranium halo, this final curve of development (Fig. 4). Halos exhibiting a character in fair conformity with the curve are not uncommon.

But, as I have said above, less exposed halos show considerable detail. We find, in fact, that separate and individual rings are developed in the growing halo. Plainly this should not be if the development was in accordance with the last curve. Under favorable conditions such recalcitrant halos are met with. It is quite

evident that they are out of agreement with the theoretical curve. The growth has not been one of uniform darkening outwards with the final addition of the penumbra due to RaC_1. And, most contradictory of all, we see that the effects of RaC_1 show themselves while
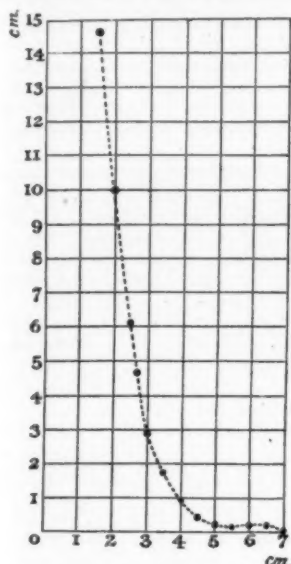

Fig. 4.—The integral curve modified by spreading of the rays

the inner rings are still in an early stage of development.

But if now we return to the first curve of development—that one which takes no account of the spreading of the rays—we find a scheme of development which closely coincides with the actual details as observed in the process of halo-growth.

First, we have a solitary ring, or shell, of ionization surrounding the nucleus. In its earlier stages it is not easy to photograph. It plainly corresponds with the first conspicuous maximum of the ionization curve (Fig. 3). This I call the first ring. The rays from U_1 and U_2 are chiefly responsible for it. This first ring, accentuated and darkened within, is often found in a succeeding stage of development along with the earliest impression of the outermost ring of all, that due to RaC_1. Next, outside the first ring, appears a very delicate and seldom-found ring, which I name the second ring. It corresponds, apparently, with the first notable excrescence on the downward slope of the curve. By the time this ring has developed, the inner region of the halo has considerably blackened up. Nor have I found this second ring without the presence of a third ring surrounding it, and evidently referable to the next excrescence on the curve. At this stage, too, we find that RaC_1 has still further registered its effects.

The stage which succeeds shows the inner detail out to the third ring obliterated in the accumulating ioniza-
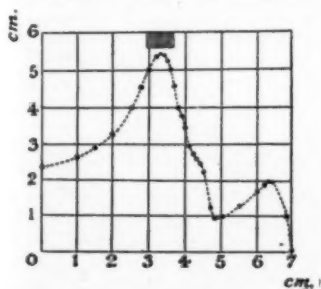
Fig. 5.—Integral curve for emanation halo showing position of first ring

tion. There is now, therefore, a central pupil surrounded by the third ring and outside all the border due to RaC_1. A yet more advanced stage finds the third ring also swallowed up in the inner darkening. This is the stage which in itself is deceptive as to the true course of development of the halo.

The successive features of the developing uranium halo have been indicated above the curve of integral ionization. The features numbered 1, 2, and 3 are the first, second, and third rings; 4 shows the limiting position of the radius of the pupil when all is blackened up within; 5 is the ring due to RaC_1.

An interesting modification of the uranium halo is found in the mica of County Carlow. The a rays of U_1 and U_2, of ionium and of radium, have apparently played no part in its genesis. The parent substance responsible for the halo is the short-lived emanation of radium. This element, and those derived from it, alone take part in its formation. Consequently, only

four out of the eight a-ray-expelling substances are concerned in its architecture. As these include the furthest reaching ray—that of RaC_1—the outside dimension of the halo is the same as that of the complete uranium halo.

When we plot the integral ionization curve of this halo we get an initiating ring of appreciably larger radius than is associated with the beginning of the uranium halo (Fig. 5). And it is by this larger initiating ring that the new halo is identified. In later stages it is difficult to differentiate it from the uranium halo.

The mode of origin of the emanation halo is interesting. All through the mica in which these halos are found there is evidence that radio-active solutions or gases were at one time transported along minute channels or cracks. These channels are bordered with radio-active darkening, showing just such an appearance as Rutherford got in the walls of a capillary tube containing condensed emanation of radium. Again, the darkening around the conduit in the mica may often possess the radial dimension of the first ring. Along such conduits we find every now and again a refracting particle which acts as the nucleus of an emanation halo. Apparently the particle has served to condense the emanation or to absorb it, and thus becomes the center of radiation for a rays given out by substances which are derived from the emanation by further disintegration. Consequently, emanation halos are found developed along such cracks or conduits, often presenting the appearance of beads upon a string.

We shall now see that the thorium halo follows faithfully the same laws of development as the uranium halo, whatever we may assume as to the nature of these laws.

By plotting the seven a-ray curves of ionization which must contribute to the formation of a halo in the medium surrounding a particle containing the parent element thorium, and then, as before, adding up the ordinates, we get for the total ionization responsible for the thorium halo the next curve (Fig. 6)

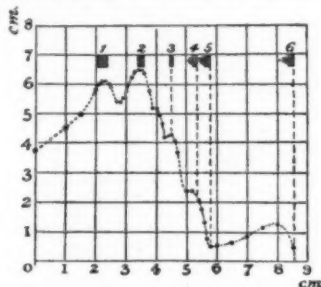Note that the single conspicuous maximum displayed by the corresponding curve for the uranium halo is now

Fig. 6.—Integral curve for thorium halo

replaced by two maxima, the one which is nearer the center being a little the lower. Beyond these two maxima the curve descends steeply with two excrescences before the minimum of ionization is reached. Then the curve reascends to the low maximum due to ThC_1.

Now, the first beginning of the thorium halo shows two rings, and the radial dimensions of these rings are in good agreement with the positions of the two maxima of the curve. The inner ring has not been found alone. Next we find the space within and around these rings growing darker, accompanied by the early appearance of the outer ring due to ThC_1, just as in the case of the uranium halo we observe the early appearance of the ring due to RaC_1. The next stage, so far certainly observed, shows the loss of the internal features, the resulting halo exhibiting much the same appearance as the uranium halo in the final stage of development.

Above the ionization curve for the thorium halo I have marked the several features of the halo. The agreement of the observed with the theoretical features is even closer than in the case of the uranium halo.

When we consider the successive steps in the genesis of the radio-active halo, which I have now laid before you, we can only come to the conclusion that some cause exists which tends to accentuate the effects going on in the outer regions of the halo. Could we assign a cause for the strengthening of the outer effects of ionization, or, what comes to the same thing, for the weakening of the inner effects, every feature of the halo becomes explained by the curve of integral ionization—that is, by the curve which simply sums the effects of the several Bragg curves. We would then find an explanation of the appearance of successive rings and of the appearance of the effects of the extreme or limiting ray at such an early stage of development.

If we assume that the process which results in the formation of a halo under the influence of the a ray is essentially similar in nature to that which is responsible for the photographic image under the stimulus of light, the desired explanation of the weakening of the inner

features is forthcoming. For the phenomenon of reversal or of solarization, well known to photographers, would assuredly lead to the weakening of the inner parts of the image. The repetition of stimuli at or near the same spot is necessarily more marked in the inner than in the outer parts of the halo, and the ionization accumulating in the region traversed by the external limiting a rays is to a large extent exempt from the effects of repetition.

Now there are features in common between the halo image and the photographic image. Both are brought about by ionization in a sensitive medium. There is so much indirect evidence for this view that we can scarcely doubt its truth. The salts of iron in many forms have been found to be photographically sensitive. In the photochemistry of chlorophyll they appear to play a fundamental part in Nature. Again, we may interpret the fact that the halo may be obliterated by heat, as proof of instability. Finally, the photographic plate is affected by the a ray in a manner not readily distinguished from that due to light.

Halos have been found which show all the appearance of reversal. In them we find the penumbra replaced by a band which is darker than the region lying within. Normal halos in its neighborhood, by contrast, well show the peculiar change which affects the reversed halo. It is the negative of a halo. What is this appearance due to, if not to reversal? The effect must arise from very intense ionization. The reversal has cleared the inner pupil more or less, but the repetition of stimuli has not been sufficient to affect the penumbra in the same manner. If these views are correct we may claim to know something of the nature of the phenomena which lead to the building up of the halo. We may regard the radio-active nucleus as emitting, for countless ages, radiations which slowly act, according to the laws affecting the latent photographic image; upon the surrounding medium. We must suppose the electric charge upon the a ray to affect the stability of the sensitive mineral, ionizing the constituent atomic systems, and, finally, producing stresses and, possibly, displacements, which are revealed in the increased color absorption.

Hitherto I have more especially dwelt upon the points of agreement between the observed and the theoretical halo. I venture to think that the agreement sets beyond any doubt not only the radioa-active origin, but also the general mode of development of halos. I shall now refer to some details in which the observed halo is not in perfect agreement with the curve of ionization.

In the case of the thorium halo the measured dimensions of the halo are in very perfect accord with the ionization curve. The agreement seems generally as perfect as we could expect. There is, however, a very small appearance of misfit in the location of the first ring. The estimates I have made of the radius of this first ring have consistently shown a small deficit. Small as it is, we should not ignore it. For there is some reason to suspect that our knowledge of the range of the a ray of thorium itself, which is largely responsible for the position of the first maximum upon the curve, is incomplete. The facts appear to show that the accepted range of the ray from thorium is too large. The evidence for this is both interesting and important.

Rutherford long ago pointed out that there appeared to exist a connection between the range of an a ray and the duration of life of the element from which it originates. The speed of the a particle seemed to be greater the shorter the period of transformation, Geiger and Nutall reinvestigated the accepted ranges of the a rays of the radioa-active elements, and established Rutherford's inference. Plotting the logarithms of the range and of the period of transformation against each other, they ascertained that for each family of elements there is a straight line along which the points found for the several a rays lie, and—in nearly every case—lie with astonishing accuracy. There is only one notable discrepancy. That exception is in the case of the range of the a ray from thorium itself. It is a few per cent too great according to the observations. It is also, admittedly, the most difficult to measure with accuracy.

Translated into the distances obtaining in the halo, that few per cent are almost beyond the limits of accuracy which may be fairly claimed. But the evidence for the slight misfit is based on many observations and may be significant.

In the case of the uranium halo there is also a discrepancy between the curve and the observations as regards the position of the first ring; but the magnitude of the discrepancy is more considerable than the misfit referred to above in the case of the thorium halo. And here we have no reason to throw the blame on any error in the accepted value of the ranges of the rays of U_1 and U_2. The curve of ionization due to the a rays of these chemically inseparable elements has been investigated by Geiger and Nutall. The results obtained are explained on the assumption that

U_1 has a range of 2.5 cm. and U_2 a range of 2.9 cm. in air. And these determinations accurately fit the logarithmic curve. The position of the maximum on the halo-ionization curve is mainly determined by these results.

Careful measurements of the first ring of the uranium halo reveal this small but definite discordance between the radius of the ring and the position of the maximum of the curve. It will be seen that the section of the ring—the feature numbered 1 in Fig. 3—does not lie accurately above the center of the maximum. The ring has a radius which is distinctly too great. That the ring essentially corresponds with the first great maximum of the curve seems beyond doubt. We find no other record of this maximum. There seems no apparent escape from the conclusion that the ring which is so largely due to the rays from U_1 and U_2 has been formed by rays of greater range than the average range of the rays now emitted by these elements.

The granite in which this halo-ring has been measured is very ancient, certainly not younger than the Devonian period. Similar rings, but not so sharp and easily measured, have been found in the carboniferous granite of Cornwall. In younger granites I have not succeeded in finding them. It would be important to measure this ring in the younger granites, supposing they have been formed in these rocks. Such measurements would make quite clear whether or not the abnormal dimension of this first ring is really due to the former existence of a longer average range of the rays responsible. If the misfit of the first ring proves to be inexplicable in any deficiency of our knowledge of the ranges of the uranium isotopes, and especially if we are able to get evidence that it is confined to the more ancient rocks, then it will be difficult to escape the direct conclusion that, however, brought about, there was a former greater range of the a ray of the parent element of the uranium family.

There is a certain temptation to accept such a conclusion, for there is a strange contradiction in the evidence advanced for the duration of geological time. The conclusion that the halo reveals a former greater range for the a ray from U_1 carries with it the former more rapid decay of that element. All the difficulties and contradictions respecting the age vanish if this indeed occurred. It will only require a few words to state the present position of the matter.

From measurements of the rates of denudative processes at the earth's surface, and of the quantities accumulated, the evidence is, with wonderful consistency, in favor of a period of about 100 millions of years having elapsed since those processes came into existence. By making certain assumptions some 150 millions of years might be claimed, and even, not inconceivably, somewhat more. What other evidence have we? The only major limit which astronomy appears to give us would be in favor of an age even less than 100 millions of years. I refer to the duration of solar heat. It is quite certain that the earth was bathed in abundant sunshine even in Cambrian times; but solar heat of the present intensity cannot be accounted for on any known source of supply for 100 millions of years. From lunar theory we do not seem able to get a major limit. We must remember that we are not discussing the age of the earth as an astronomical unit. The geological age is the period of denudation only. Well, then, a generation ago very brilliant work was done by Kelvin on the period since the solidification of the surface rocks. But the thermal data involved became invalidated in the light of Strutt's discovery that heat-producing radio-active elements exist all over the earth's crust.

But if radio-active science in this way has closed one avenue of approach to the age problem, it has opened up another. Rutherford pointed out that the accumulation of radio-active products of decay in ancient rocks and minerals should afford a measure of the age in much the same manner as, from the amount of sand which has fallen through, we compute time by the hour-glass. In this connection Strutt's work on the amount of helium accumulated in materials of various geological ages will ever be memorable. The amount of accumulated lead, however, possesses, in some respects, less liability to error. The measurement of the ratio of the quantity of lead to the quantity of parent radio-active element in the case of uranium has occupied the attention of several investigators. The conclusion as regards the accumulation of lead in uranium-bearing minerals seems to be—although not without conflicting evidence—that the earth's geological age is not less than some 1,500 millions of years.

Now, while we must admit the possibility of considerable variations in the rate of denudation over the past, yet the statement that the rivers are now pouring some ten times as much dissolved matter into, and transmitting some ten times as much sediment to, the ocean as they did in past times is, I think, quite inadmissible. All efforts to explain so extraordinary an increase—whether we suppose it to be temporary or permanent—have so far failed.

But the uranium series of radio-active elements is not the only one available in the application of Rutherford's method of computing the age. There is quite as good evidence that the thorium series ends in an isotope of lead as there is for the same conclusion repecting the uranium series.

Now, in dealing with the atomic weight of the lead found in Ceylon thorite, Prof. Soddy recently carried out, on a large scale, a very careful chemical analysis of this mineral, and determined the quantity of lead present. When we calculate, on the basis of his results, the age of the mineral, we get about 140 millions of years. The rocks to which this determination applies are very ancient—certainly pre-Cambrian. The result is, therefore, in good agreement with the conclusion derived from denudation. Is this a mere coincidence?

Before this recent result it was known that the indications of thorium-derived lead were opposed to those of uranium-derived lead, and those who upheld the longer age urged that the lead derived from thorium must be unstable, and must turn into something else over geological time. But the view that thorium lead is not permanent is one beset with difficulties.

From this we see that the uranium and the thorium families of elements give, at the present time, contradictory evidence respecting the age of the earth. The latter apparently agrees in a remarkable manner with the indications of the surface changes of the globe; the former does not. And now the measurements of the uranium halo admit of the interpretation that they indicate the failure of uranium-derived lead as a true indicator of geological time. For if the range of U^1 was, indeed, in remote times longer than it now is, then we must suppose that its rate of decay was at that period faster than it is today. Or we may suppose that, however, derived, in remote times relatively short-lived uranium isotopes existed which have died out during geological time. I am far from contending that this view is free from difficulties. On the other hand, our ignorance of the mode of origin of radio-activity and of its possibilities is very considerable.

If we have to admit that the evidence of the halo on the age problem is not yet complete, we can refer to a still more important matter upon which the testimony of the halo admits of no uncertainty. Until the radio-active origin of halos was ascertained it was impossible to pronounce on how far, in remote periods of earth-history, radio-activity might have affected the chemical elements. Thus it would have been a quite allowable speculation to suppose many of the elements to have been derived as end-products of radio-active families the activity of which has only comparatively recently become extinct. The halo enables a very general answer to be given to such speculations. A substance such as brown mica—and this is one of the most widely diffused of rock minerals—is sensitive to a radiation, and integrates its effects with the same certainty as the photosensitive plate integrates the effects of light. A mineral containing a minute trace of a radio-active substance beams, throughout the ages of geological time, upon the medium in which it is contained. If the medium is sensitive the accumulated effects in general persist for our inspection, and in the halo we are, in consequence, able to identify the presence of quantities of radio-active substances of almost inconceivable minuteness. Imagine that stellar magnitude which would be recorded upon a photographic plate exposed uninterruptedly for scores of millions of years.

We see from this that the *unaffected* plate of mica is evidence for the absence of even the feeblest a radiation from surrounding or included elements, just as the blank photosensitive plate is proof of the absence of luminous influence. No definite halo-producing effects have been observed other than those which may be referred to the known radio-active elements.

Thus we find that the study of the conditions which call the halo into existence affords a criterion for determining the absence of any general elemental evolution during the period of geological time. When geological time began any earlier evolutionary process must have already come to an end, with the sole exceptions of the known families of radio-active substances. This result, which is *a priori* by no means evident, is of importance to our views on the physical history of the earth. Only from the minute hieroglyphics we have been considering could such information have been derived.

Effect of Pressure on Metals

SOME experiments on the effect of great hydrostatic pressures on the physical properties of metals were described before the Institute of Metals by Professor Zay Jeffries, of Cleveland, Ohio.

Cylinders measuring 7/16 in. in diameter by ½ in.

in length were prepared of pure aluminium and of an alloy containing 88 per cent of aluminium and 12 per cent of copper. In the first tests cylinders of both kinds were exposed to a hydrostatic pressure of 12,400 kg. per sq. cm. (about 70 tons per sq. in.) at a temperature of 25 deg. C.; the transmitting liquid was petroleum either mixed with kerosene, and the pressure was maintained near the maximum for 20 minutes, the total time occupied in raising the pressure to the maximum and releasing being about 2½ hours. In the second tests the conditions were the same, except that the temperature was 40 deg., and kerosene was used as the transmitting medium. In neither set of experiments could any change of shape be detected, and there was practically no effect on the hardness and tensile strength of either the pure metal or the alloy. Further, the microstructure of the metals seemed to be the same before and after subjection to the hydrostatic pressure. These results contradict those published by Hanriot in 1912, since he obtained an increase in hardness of 30 per cent on aluminium, though the cubes of metal he used were not appreciably deformed, by the application of a hydrostatic pressure of about 10,000 kg. per sq. cm. (63 tons per sq. in.).

Back Numbers of the Scientific American Supplement

SUPPLEMENTS bearing a date earlier than January 1st, 1916, can be supplied by the H. W. Wilson Company, 39 Mamaroneck Avenue, White Plains, N. Y. Please order such back numbers from the Wilson Company. Supplements for January 1st, 1916, and subsequent issues can be supplied at 10 cents each by Munn & Co., Inc., 233 Broadway, New York.

Table of Contents